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A REVISION OF SOME PLANTS FROM THE PERMIAN OF THE BOWEN BASIN, QUEENSLAND

by

J. F. RIGBY

GEOLOGICAL SURVEY OF QUEENSLAND

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By J. F. Rigby

Geological Survey of Queensland

SUMMARY

Permian plant species based on material from the Bowen Basin, Queensland, are redefined and refigured photographically. They comprise *Glossopteris jonesii* Walkom, *Plumsteadia microsacca* Rigby, *Samaropsis dawsonii* (Shirley) Walkom, *Samaropsis Etheridgei* Walkom, and *Nummulospermum bowenense* Walkom.

INTRODUCTION

Species from the Permian Lower Gondwana flora for which the type specimens are housed in Queensland are reviewed, and when necessary, redefined. They comprise the following species:

Glossopteris jonesii Walkom, 1922.
Plumsteadia microsacca Rigby, 1963.
Samaropsis dawsonii (Shirley) Walkom, 1922.
Samaropsis Etheridgei Walkom, 1922.
Nummulospermum bowenense Walkom, 1921.

There has been a tendency to ignore the species listed above, with the exception of *Nummulospermum bowenense*. This has been because of lack of information concerning them.

This revision is necessary before a biostratigraphic survey of the Upper Palaeozoic floras of the Bowen Basin can be attempted. Future publications will cover other aspects of the flora, including reference to species described from Queensland for which the type specimens are not stored in Queensland.

Where necessary, spelling of specific epithets has been amended to conform with the following provisions of the 1966 edition of the International Code of Botanical Nomenclature: Note 3 of Article 73 concerning the wrong use of endings, and Recommendation 73c concerning remedial action.

Catalogue numbers of specimens are prefixed by GSQ when held by the Geological Survey of Queensland, and UQ when held by the Department of Geology and Mineralogy, University of Queensland.

SYSTEMATIC PALAEOBOTANY

All species discussed are assigned to form genera.

Division	GYMNOSPERMAE
Class	CYCADOPSIDA
Genus	GLOSSOPTERIS, Brongniart, 1822

Glossopteris jonesii Walkom, 1922

Figures 1a - c

1922 *Glossopteris jonesii* Walkom, pp. 19-20, pl. 6, figs. 29-32.

Discussion:— Walkom erected this species for some leaves from the "Lower Bowen Volcanics" at Threemile Creek, Bowen Coalfield. A minor amendment is necessary to his description.

Specimen GSQ F 1855 is chosen as the lectotype — the specimen figured by Walkom (1922) as pl. 6 fig. 29, refigured here as fig. 1a. Walkom's other figured specimen, F 1854, is a paratype. A second specimen on the same slab of rock as the lectotype is shown here as fig. 1b. The lectotype has been chosen by me from amongst the specimens originally figured by Walkom as it is the only one to show the venation clearly. The line drawing (fig. 1c) shows that the vein spacing is closer towards the margin, not uniform throughout the leaf as thought by Walkom.

Comparisons:— Walkom (1922) compared *Glossopteris jonesii* with leaves of *G. parallela, G. taeniopteroides* and *G. occidentalis*, and separated it from them on the basis of their venation. Many additional species of *Glossopteris* have been described since 1922, none of which resemble *G. jonesii*.

Type specimen:— GSQ F 1855 (fig. 1a)

Distribution:— Given by Walkom (1922) as "Lower Bowen Series, Three Mile Creek, Bowen Coalfield". According to Reid (1929, p. 59) this locality lay within the "lowest beds of the Middle Bowen". This has been confirmed by recent mapping which shows that Three Mile Creek flows over beds of the Blenheim Formation.

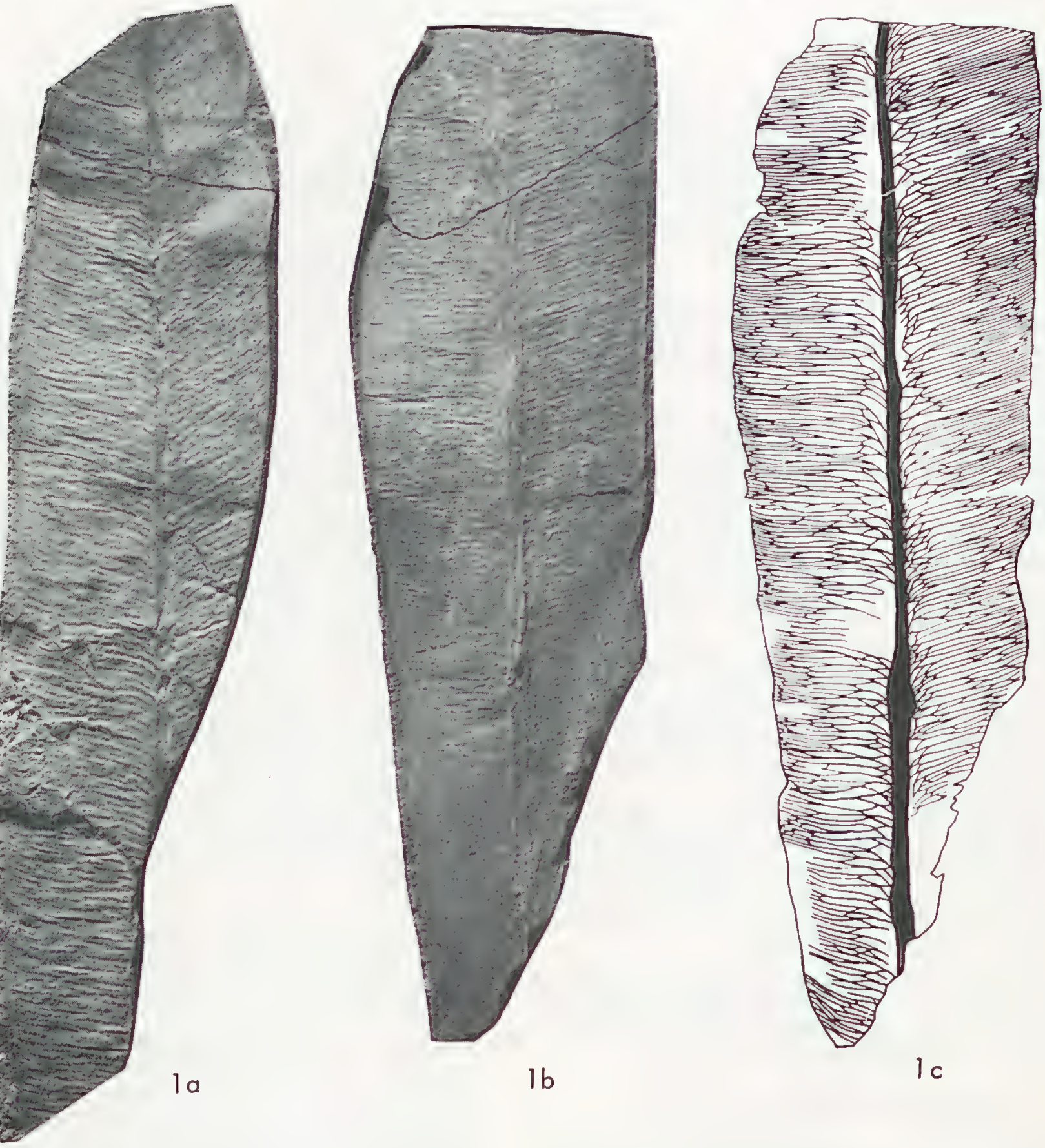
GLOSSOPTERID FRUCTIFICATIONS

New species have been described from Queensland; some from Baralaba are discussed here.

Rigby (1963) described *Plumsteadia microsacca* gen. et sp. nov. White (1964) described *Cistella bowenensis* sp. nov. These determinations need review as there appears to be confusion in the application of generic names. It is necessary to discuss various genera of glossopterid fructifications before applying their names to these Queensland specimens.

The following genera are recognized at present or have been in the past, although their true nature has yet to be explained; none has been recognized as seed bearing:—

FIGURE 1
Leaves of *Glossopteris jonesii* Walkom, 1922, x 1.
a. Lectotype, GSQ F 1855; b. Another specimen from the type collection, not figured previously, part of GSQ F 1855; c. Venation of previous specimen, fig. 1b.



Dictyopteridium Feistmantel, 1881, ex Zeiller, 1902;
Ottokaria Zeiller, 1902, replacing *Feistmantelia* Zeiller, 1902, preoccupied;
Scutum Plumstead, 1952;
Lanceolatus Plumstead, 1952;
Cistella Plumstead, 1958, *non* Blume, 1825 *non* Quélet, 1886;
Pluma Plumstead, 1958;
Lidgettonia Thomas, 1958;
Plumsteadia Rigby, 1963;
Vannus Plumstead, 1967.

Of these *Ottokaria, Pluma, Lidgettonia,* and *Vannus* do not concern us further as they bear no resemblance to any of the specimens under discussion from Queensland. The remaining genera possess, or appear to

possess according to some authors, some features in common that have caused confusion in the application of names. The problem is not great when the fructification is found attached to a glossopterid leaf, but unfortunately most specimens are known only in a detached state.

Each fructification consists of a central body that may be bilaterally symmetrical, or as has been suggested by some, radially symmetrical. The central body is clothed by dozens or in some cases hundreds of small sac-like bodies. In *Lanceolatus* the central body develops and remains within the tissue of the supporting leaf, whereas in the other genera the organ projects from the midrib or the petiole of the leaf.

Plumstead (1952) originally erected *Scutum* as the alternative to *Lanceolatus* where the sac-bearing central body was pedicellate, growing as a process from the midrib or the petiole of a leaf. The central body is fringed by a marginal wing, more often than not both ribbed and serrate. In 1958, Plumstead separated *Hirsutum* from *Scutum* basing this on a previous opinion — it has "strand like staminate organs and the association with firm thick or coriaceous vegetative leaves" (Plumstead, 1956, p. 20). She never gave a generic diagnosis, and the characters she refers to appear somewhat tenuous as they are based partly on interpretation, not on direct observation of the specimen. Mukherjee *et al.* (1966) consider the erection of *Hirsutum* to be inopportune, as do I.

Plumstead (1958, p. 65) erected *Cistella* for fructifications having a free central body, but with a petiole adnate to the supporting leaf. The marginal wing is absent. *Cistella* is preoccupied so the suggestion of Rigby (1969) that *Plumsteadia* be used is followed. *Plumsteadia* is redefined below.

Feistmantel (1880/81, pl. XXIII A, figs. 4, 5, 6, 14) identified some isolated specimens of fructifications, similar to the ones recognized by Plumstead, as *Dictyopteridium sporiferum*, but did not provide a description. The specimens figured appear to have been similar to *Plumsteadia*, differing only by having the sacs or tubercles separated instead of tightly packed. Feistmantel (1886, pl. VA, fig. 3) identified a specimen as *Dictyopteridium*, again not providing any form of description. This latter specimen appears to be an example of *Plumsteadia*. He thought that these specimens may have been examples of fertile fern fronds.

Zeiller (1902, p. 24, pl. IV, fig. 8) figured and provided a full description of a specimen which he named *Dictyopteridium sporiferum*. His specimen shared with Feistmantel's examples the characteristic of spacing between the sacs, but differed considerably in shape. Zeiller validated the use of the name by giving an analysis. He thought it might have been a root or a fleshy rhizome.

Since then a number of isolated fructifications have been described variously as *Dictyopteridium sporiferum* (for example, by Walkom, 1922) or *Conites* (for example, by Seward, 1908). Some specimens have been referred to *Dictyopteridium sporiferum* since the publication of Plumstead's work (1952). These have all been isolated, usually having the appearance of *Plumsteadia*, but some, for example, those of Maheshwari (1965, particularly pl. 1, figs. 2 and 3) have the sacs separated by other tissue on the surface of the fructification, and similar to the specimens originally figured by Feistmantel (1880/81, not 1886) and Zeiller (1902). Originally I favoured using *Dictyopteridium sporiferum* for all isolated fructifications (Rigby, 1963), but now realize that this leads to unnecessary confusion. Of the attached fructifications listed above, only *Lanceolatus* cannot occur isolated, as noted by Mukherjee *et al.* (1966).

Genus Plumsteadia Rigby, 1963

Diagnosis:— Compound fructifications consisting of numerous sacs or tubercles packed tightly together over one surface of a leaf-shaped organ, which is basally adnate to the midrib of a glossopterid leaf. Sacs probably microsporangiate. Wing absent.

Discussion:— This genus of glossopterid fructification originally bore the name *Cistella*, which was preoccupied. White (1964, p. 395) suggested that *Cistella* and *Plumsteadia* were the same, and this was accepted by Rigby (1969), who proposed that the genus be known as *Plumsteadia*.

Types species:— *Plumsteadia microsacca* Rigby, 1963.

Plumsteadia microsacca Rigby, 1963
Figures 2a - c

1962 *Lanceolatus* sp., in Rigby, pp. 196-198, fig. 1.
1963 *Plumsteadia microsacca* Rigby, pp. 344-345, pl. XI, fig. 5.
1963 *Dictyopteridium sporiferum* (pars), in Rigby; pp. 345-346; pl. XI, fig. 3.
1964 *Cistella bowenensis* White, pp. 394-395, pl. XXIV, fig. 12 only.

Diagnosis:— Compound fructification consisting of numerous sacs or tubercles packed tightly together over one surface of a lanceolate, narrowly ovate structure, apex narrowly acute to acuminate, base rounded, attached basally without significant petiole to lower part of midrib of leaf of *Glossopteris communis* Feistmantel. Sacs larger around margin of fructification than sacs away from margin.

Discussion:— A careful comparison of the type specimen of Rigby, specimen UQ F 31956 (fig. 2a), and the type specimen of White, specimen GSQ F 3185 (fig. 2c), shows that the leaves on which the fructification grew are identical, and represent a somewhat narrower than usual form of *Glossopteris communis* Feistmantel. The fructifications differ somewhat in shape, but the sacs they bear are only slightly different in size, those of specimen UQ F 31956 are smaller, hence the fructification is probably less mature.

FIGURE 2

Plumsteadia microsacca Rigby, 1963. a. Holotype, UQ F 31956, x 2; b. Specimen originally described as detached, but now recognized as attached to the mid-rib of a leaf. The fructification is a mould. UQ F 31957, x 2; c. Specimen originally described as holotype for *Cistella bowensis*. GSQ F 3185, x 2.

A re-examination of specimen UQ F 31956 (fig. 2b) identified as *Dictyopteridium sporiferum* by Rigby (1963), shows that it is attached to a small fragment of leaf.

The range of variation of size and shape is indicated by the following data:—

Specimen	UQ F 31956 fig. 2a	UQ F 31957 fig. 2b	GSQ F 3185 fig. 2c
length in mm	24	33	31
breadth in mm	10	9	8

This size range may be expected in a compound fructification.

Comparison:— *Plumsteadia stricta* (Plumstead) Rigby is proportionally much shorter and broader, and is attached to a leaf having a different venation. *P. waltonii* (Plumstead) Rigby has much more strongly developed sacs, distinctly differentiated into marginal sacs of different proportions to sacs away from the margin. Specimens identified as *Cistella ampla* by White (1964) appear to belong in some other genus, so do not concern us here. *Plumsteadia indica* (Maheshwari) Rigby is a much broader fructification relative to the breadth of the supporting leaf.

Type specimen:— UQ F 31956, (fig. 2a).

Distribution:— Baralaba Coal Measures. Roof of the Dawson Seam, Baralaba: UQ F 31956, UQ F 31957. Shales immediately above the Dunstan Seam, Baralaba: GSQ F 3185.

Division GYMNOSPERMAE
Genus SAMAROPSIS Goeppert, 1864

Samaropsis dawsonii (Shirley) Walkom, 1922
Figures 3a-b

1902 *Cycadospermum dawsoni* Shirley, p. 9, pl. III.
1922 *Samaropsis dawsoni*, in Walkom, pp. 34-35, pl. 8, figs. 40-42.
1962 *Samaropsis dawsoni*, in White (1962/114), p. 4, pl. 3, figs. 5, 7.
1964 *Samaropsis dawsoni*, in Hill & Woods, pl. PXIV, fig. 12. Doubtful record.
1961 *Samaropsis dawsoni*, in White (1961/60), p. 6, fig. 12.

Diagnosis:— Sclerotesta ovate, rounded or slightly cordate at base, tapering towards apex, which is frequently bifurcate; sclerotesta 24 - (21) - 17 mm in height, 18 - (15) - 11 mm in breadth. Sarcotesta insignificant towards apex, but forming a distinct wing in the lower part of the seed with basal lobes up to 5 mm long; width of wing at broadest part of seed, up up to 2 mm. Wing absent below hilum. Hilum situated on one side, centrally just above the base, 3 mm long, 1.2 mm wide. Median ridge extending from base of apical bifurcation towards base of seed, dividing the seed into two equal halves.

Description:— Twenty-two seeds and a number of fragments, all part of the material originally described by Shirley (1902) and redescribed by Walkom (1922) formed the basis of this diagnosis. The dimensions given are based on 22 more or less complete seeds. The uniformity of size indicates that the seeds are mature.

In addition to the information already reported by Walkom (1922, pp. 34-35) it is noted that most seeds are slightly distorted. Careful measurements relative to the vertical axis of symmetry show that the distortion is not significant in most specimens, where it is significant the seeds have been rejected. Distortion appears to have occurred after partial consolidation of the sedi-

FIGURE 3

Samaropsis dawsonii (Shirley) Walkom, 1922. a. Holotype of Shirley. GSQ F 1518, x 2; b. Portion to left of seed body is separated by selvidge of rock matrix which is visible near apex. GSQ F 1901, x 2.

ments. Most seeds have distorted without fracturing, other than for the dichotomous splitting of the apex. A few seeds appear to have rolled instead of distorted as one edge is folded over and the other under so as to give the seed an S-shaped cross section.

Shirley (1902, p. 9) noted the cleft present at the apex in some specimens, and suggested that it may have been caused by pressure. It does not appear to be a natural bifurcation as found in the genus *Cornucarpus*, for example, although it is sufficiently common to be considered as a supporting feature in specific determination. He also suggested that the median ridge was caused by pressure, but as this is a common feature in many fossil seeds, it is considered to be a normal character in agreement with Walkom (1922).

Specimen GSQ F 1901 (fig. 3b), figured by Walkom (1922, pl. 8, fig. 40), has what he interpreted to be a sarcotesta up to 6 mm broad on the left of his figure. Careful examination of the specimen reveals that the wing is separated from the sclerotesta by a thin selvidge of sediment, therefore does not form part of the seed.

Comparisons:— *Samaropsis dawsonii* differs from *Samaropsis milleri* (Feistmantel) Seward as it has wings in the sarcotesta at the base, and lacks a wing in the sarcotesta towards the apex. Most seeds of *S. milleri* are considerably larger than the seeds of *S. dawsonii*. *S. milleri* was originally reported from India; there has been a tendency to place all Lower Gondwana large seeds in this species.

Samaropsis indica (Zeiller) Seward has a sarcotesta similar to *S. milleri*, but also has a median ridge. It is known from the Karharbari Stage of India.

The comparison of *S. dawsonii*, as "*Cardiocarpus* sp. (from Australia)", by Arber (1905 p. 207) with the nomen nudum *Carpolithes Tasmanicus* Johnston (1888, pl. VIII, fig. 7) appears unjustified. The sketch given by Johnston bears little resemblance to any specimens of *S. dawsonii*, in fact the seed shown in the sketch is generically indeterminate.

Samaropsis leslii Seward has a sclerotesta approximately the same size as in *S. dawsonii*, but without the strong medial ridge. *S. leslii* has a broad sarcotesta towards the apex. It occurs in the Ecca Series of Transvaal.

S. milleri, *S. indica*, and *S. leslii* all had a somewhat broader seed body than *S. dawsonii*, a difficult character on which to base specific separation.

Samaropsis intermedia Høeg & Bose is described as intermediate between *S. milleri* and *S. indica* (Høeg & Bose, 1960). It has the same apical sarcotesta and broader shape to the seed body, as have these two other species. It occurs in the Permian coal measures of Congo.

The specimen figured by Høeg & Bose (1960, pl. XII, fig. 2) as "*Samaropsis* Goepp. or *Cordaicarpus* Sew", which they describe as a comparison, cannot be considered as identical. It occurs in the Walikale black shales of Congo (Permo-Carboniferous).

Type specimen:— GSQ F 1518 figured by Shirley (1902, pl. III), see fig. 3a.

White (1961/60, p. 6, fig. 12) recorded a specimen as *Samaropsis dawsoni*. Later she amended the identification to *Samaropsis* sp. (White, 1964, p. 72, pl. 6, fig. 1).

Distribution:— (As given by Shirley; 1902, p. 9) "Dawson River, Anthracitic (B) Series, Lower Bowen". Dunstan (1901, p. 12) described this "Series". Later Reid (1929, p. 103) placed it in the lower part of the Upper Bowen, and it corresponds to the Baralaba Coal Measures in recent nomenclature. GSQ F 1518 (fig. 3a), GSQ F 1901, GSQ F 1902, GSQ F 1903. Carmila Beds, Mackay 1:250,000 sheet (reported by White, 1966). Locality M 423, 3 miles north of Range Hotel on Nebo — Eton Road; Locality M 754, 10 miles south-west of Mackay.

Samaropsis Etheridgei Walkom, 1922
Figure 4a

Discussion:— The species is based on a single specimen, GSQ F 1810, (fig. 5a). Walkom (1922, p. 35) gave the following diagnosis: "Seed subcircular, 10 mm high, 9 mm broad; consisting of sclerotesta 7 mm by 5.5 mm, surrounded by wing of almost uniform width; truncate at base, very obtusely pointed at apex", to which should be added "slender micropyle present".

The seed is slightly distorted.

The figure given by Walkom (pl. 9, fig. 50) is a sketch, and does not emphasize the truncate nature of the basal portion of the sarcotesta sufficiently. It is slightly lobed at each side of the portion assumed to represent the attachment. This is 2 mm wide. Many other Lower Gondwana seeds have a similar lobing in the sarcotesta at the base when the wing is continuous around the apex, but in all other cases known to me there is either no truncate portion, e.g. *Samaropsis goraiensis* Surange & Lele (1957, pl. 1, fig. 3), or the lobing is so strongly developed that it is twice as wide as the lateral wing, e.g. *Samaropsis criciumensis* Millan (1967, pl. 1, fig. 7). A fine micropyle passes through the sarcotesta at the apex. There is a faint suggestion of longitudinal ribbing on the body of the seed.

Walkom (1922, p. 35) considered that the specimen from Newcastle, N.S.W., figured by Arber (1902, text fig. on page 20) as *Cardiocarpus* sp. was "apparently the same" species as *S. Etheridgei*. I prefer considering the record from New South Wales as a comparison. Walkom (1922 also compared his species with a specimen from India described by Zeiller (1902, p. 38, pl. VII, fig. 11) as *Cardiocarpus* sp. This latter specimen had an acute apex, not almost rounded as in *S. Etheridgei*.

Type specimen:— GSQ F 1810, fig. 4a.

Distribution:— "Upper Bowen Series", Near Pentland (from Walkom, 1922), this appears to correspond to the Betts Creek Beds. GSQ F 1810.

Genus NUMMULOSPERMUM Walkom, 1921

1921 *Nummulospermum* Walkom, p. 290.

Remarks:— Walkom (1921) erected this genus for the reception of certain seeds of *Samaropsis* for which some anatomical information was available. Because of this he quite justifiably considered that they warranted a more distinctive name than *Samaropsis*.

Nummulospermum bowenense Walkom, 1921

Figures 4b - e

1921 *Nummulospermum bowenense* Walkom, pp. 289-295, pl. XXI, text fig.

1922 *Nummulospermum bowenense*, in Walkom, pp. 26-27, pl. 7.

1965 *Nummulospermum* cf. *bowenense*, in Maithy, p. 50, pl. 2, fig. 13.

Discussion:— Specimen GSQ F 1900 (fig. 4b) bears 28 complete or fragmentary seeds, four of which are labelled. These have been reproduced as various figures by Walkom (1921, 1922) as detailed below:—

Number on Specimen	Figure number on pl. XXI of Walkom, 1921	Figure number on pl. 17 of Walkom 1922	Figure number this publication
36	3	36	4c
37	4	37	4d
38	—	38	4e
39	2	—	4f

Plate XXI, fig. 1 and pl. 7, fig. 34 are reproductions of the entire specimen, apparently using the same negative, but at different orientations on the plate. The rock slab has been reproduced here (fig. 4b) in order to indicate the numbered specimens. The specimen marked by the number 36 is selected as the type specimen as it has been reproduced in both papers by Walkom (1921, 1922), the other numbered specimens are nominated as paratypes.

Walkom mentioned other specimens he included in the species (1921, p. 292 and quoted in 1922, p. 28):—

"From Minnie Creek, there is also a single seed, probably an example of *Nummulospermum bowenense* . . . " This specimen GSQ F 1914 (fig. 4g), bears a seed that lacks a sarcotesta. Its margin is somewhat rough, hence the sarcotesta may have been present then destroyed after falling from the parent plant. The seed body is 6.5 mm long and 7 mm wide has a broad base, 3mm, but has the pointed apex of *Nummulospermum*. None of the anatomical features of *Nummulospermum* are present, neither is the typical wing of *Samaropsis*. It bears a very strong resemblance to the sclerotesta of *S. Etheridgei* both in size and shape. I prefer considering this specimen as a record of *Samaropsis* sp. and not attributing it to a species dependent on the presence of certain anatomical structures.

"From Barwon Park, there are three flattened seeds, also probably *N. bowenense* . . ." These seeds occur on the part numbered GSQ F 1913 and its counterpart. They are poorly preserved; only one has a wing, but all are of the same species, which is *N. bowenense*.

Besides the records of Walkom, a number of others have been listed, but neither figured nor described, by White (in unpublished Records of the Bureau of Mineral Resources, Canberra). These cannot be reviewed.

The specimens identified by Maithy (1965) appear to be conspecific. They occurred in the Karharbari Stage, India.

Renier (1951, pl. 4, fig. 20) identified a seed as cf. *Nummulospermum* from the Congo. His figure suggests that the specimen has little in common with *Nummulospermum*.

FIGURE 4

a. *Samaropsis Etheridgei* Walkom, 1922, holotype. GSQ F 1810, x 2.

b-f. *Nummulospermum bowenense* Walkom, 1921. b. Rock slab showing the position of Walkom's numbered specimens GSQ F 1900, x $\frac{1}{2}$; c. Walkom's specimen 36, lectotype, x 2; d. Walkom's specimen 37, x 2; e. Walkom's specimen 38, x 2; f. Walkom's specimen 39, x 2.

g. *Samaropsis* sp. GSQ F 1914, x 2.

Type specimen:— No. 36 on specimen GSQ F 1900 (fig. 4c), lectotype.

Distribution:— Given by Walkom (1922) as Lower Bowen Series. Reid (1929, p. 59) has pointed out that the "Three Mile Creek, Bowen Coalfield" locality lies within the Collinsville Coal Measures; Walkom's specimen: GSQ F 1900. Walkom gave a second locality as "Barwon Park", which has been mapped recently as undifferentiated Blackwater Group; Walkom's specimen: GSQ F 1913.

Karharbari Stage: Central Pit, Srirampur Colliery, Giridih Coalfield, India, reported by Maithy (1965).

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GONDWANIDIUM AND OTHER SIMILAR UPPER PALAEOZOIC GENERA, AND THEIR STRATIGRAPHIC SIGNIFICANCE

by

J. F. Rigby

Geological Survey of Queensland

April, 1973

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by
J. F. RIGBY
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SUMMARY

Some of the plants from eastern Australia, Argentina, Peru, and Kashmir, indentified as *Rhacopteris,* are fragments from fronds of the genus *Gondwanidium;* others belong in the Upper Carboniferous species *Pseudorhacopteris ovata* (McCoy) gen. et comb. nov. The latter characterizes the Pseudorhacopteris Flora. Occurrences of this flora are best documented in New South Wales, where its range is Namurian—Westphalian. The Gondwanidium Flora succeeds the Pseudorhacopteris Flora near the local Westphalian—Stephanian boundary in New South Wales.

INTRODUCTION

The generic identity of plants referred to *Rhacopteris* in Australia, Peru, and Kashmir has been in doubt. There has also been confusion between rhacopterid foliage and *Gondwanidium.* Rhacopterids with fine, interveinal striations on expanded pinnae (see Dun, 1905, p. 158, and Steinmann, 1929, p. 33) are placed in a new genus, *Pseudorhacopteris.* Both *Gondwanidium* and *Pseudorhacopteris* may be foliage of pteridospermous plants, but proof is not possible, as fertile structures have not been found.

Specimen numbers are prefixed as follows to indicate the repository:— AM Australian Museum, Sydney; GSQ Geological Survey of Queensland, Brisbane; MM Mining Museum, Geological Survey of New South Wales, Sydney.

SYSTEMATIC PALAEOBOTANY

Genus PSEUDORHACOPTERIS gen. nov.

Diagnosis:— Fronds consisting of an apparently unbranched rachis, bearing sessile or shortly petiolate pinnae. Pinnae triangular, flabelliform, cuneate or subcircular, contracted at base, lying more or less in plane of rachis; apical margin of pinna entire, serrate, or slightly lobed. Venation dichotomous, radiating from pinna base; midrib absent; interveinal lineations fine, variable in number, more prominent in larger pinnae. Adjacent pinnae may overlap slightly.

Type Species:— *Pseudorhacopteris ovata* (McCoy) Rigby, comb. nov.

Discussion:— This genus is erected for fern-like fronds which were formerly included in the genus *Rhacopteris. Pseudorhacopteris* differs from *Rhacopteris* in having fine lineations between veins in the pinna. These lineations may reflect the presence of fibres in the mesophyll, or of hypodermal sclerotic masses such as those of *Cordaites* described by Harms and Leisman (1961, p. 1043).

Pseudorhacopteris ovata (McCoy) Rigby, comb. nov.
Pl. 1, fig. 1; pl. 2, figs 4-6; pl. 3, figs 12B-13

1847 *Otopteris ovata* McCoy, p. 148, pl. IX, fig. 2.
1876 *Otopteris argentinae* Geinitz, p. 6 pl. II, figs 5a, 5b.
1878 *Rhacopteris* cf. *inaequilatera* Goeppert, in Feistmantel, pp. 74-75, pl. II, fig. 3; pl. III; Pl. IV, figs 1,2.
1879a *Rhacopteris inaequilatera* Goeppert, in Feistmantel, pp. 145-147 (pars), pl. XIX, figs 3, 4; pl. XX figs 1, 3; pl. XXI; pl. XXII, figs 2, 3; pl. XXIII, figs 4, 5; pl. XXIV, fig. 2.
1890 *Rhacopteris inaequilatera* Goeppert, in Feistmantel, pp. 97-99 (pars), pl. IV; pl. V; pl. VI, fig. 1; pl. VII, figs 1, 3; pl. VIII; pl. IX.
1905 *Aneimites ovata* (McCoy) Arber, in Dun, pp. 157-159, pl. XXII, fig. 3; pl. XXIII.
1921 *Rhacopteris inaequilatera* var *ovata* Kurtz, p. 146.
1929 *Rhacopteris circularis* Walton, in Steinmann, p. 32, fig. 29.
1934 *Rhacopteris ovata* (McCoy) Walkom, in Walkom, pp. 431-432 (pars).
1937 *Rhacopteris ovata* (McCoy) Walkom, in Gothan and Sahni, pp. 198-200, pl. 16-17.
1938 *Rhacopteris ovata* (McCoy) Walkom, in Read, p. 401, fig. 1.
1943 *Rhacopteris ovata* (McCoy) Walkom, in Frenguelli, p. 14, pl. 1; pl. 3, fig. 2(?); pl. 4, figs 1(?), 2, 3(?).
1946 *Rhacopteris ovata* (McCoy) Walkom, in Frenguelli, pl. 2, figs 1, 2.
1954 *Rhacopteris ovata* (McCoy) Walkom, in Jongmans, pp. 212-213, pl. 25, figs 33-37; pl. 26, fig. 45.

1954 *Rhacopteris* cf. *circularis* Walton, in Jongmans, pp. 213-214, pl. 25, fig. 38; pl. 26, fig. 39.
1966 *Rhacopteris ovata* (McCoy) Walkom, in Archangelsky and Arrondo, pp. 6-12, pl. II, figs 1-4, pl. III, fig. 1.

Doubtful record

1965 *Rhacopteris ovata* (McCoy) Walkom, in M. White, pl. 4, fig. 5.

Diagnosis:— Pinnae alternate, cuneate or flabelliform, shortly petiolate, margin serrate or entire. Anatomical and cuticular data unknown.

Description:— Rachis of specimen AMF17497 (pl. 1, fig. 1; pl. 2, figs 4, 5, 6) apparently unbranched and 285 mm long. Pinnae alternate; obovate with an entire margin in apical part of the frond (pl. 2, fig. 4); cuneate with a crenulate apical margin, in lower portion. Pinnae shortly petiolate, inserted laterally to rachis. One or a small number of veins at base of each pinna; veins dichotomise many times before intersecting pinna margin. In pinnae with crenulate margins, the veins intersect the margin at cusps. Lineations between veins fine, variable in number; usually about six, 0.25 to 0.5 mm apart (pl. 2, fig. 5). Lineations arise within the interveinal tissue.

Type Specimen:— L6 in the Foreign Plant Collection, Sedgwick Museum, Cambridge. Locality—Arowa, New South Wales.

Discussion:— There has been considerable confusion concerning the generic and specific identity of *Otopteris ovata* McCoy (1847, p. 148, pl. IX, fig. 2), described from "the hard siliceous flags of Arowa, New South Wales". Feistmantel (1879a; 1890, p. 98) included *Otopteris ovata* as a synonym under *Rhacopteris inaequilatera* Goeppert. In the 1890 publication the legend to pl. 6, fig. 1 reads "*Rhacopteris inaequilatera,* Goepp. Arowa (the original *Otopteris ovata,* McCoy)", although the specimen shown is not McCoy's. Arber (1902) revised the Clarke Collection of fossil plants described by McCoy (1847) and noted that Sedgwick Museum specimen L6 was the type of *Otopteris ovata.* He included *Aneimites austrina* Etheridge Jr (1888) in McCoy's species, and compared his revised *Aneimites ovata* (McCoy) Arber with *Neuropteris (Neuropteridium)* Schimper. Dun (1905) correctly excluded *Aneimites austrina.* Etheridge Jr's specimen, refigured here as *Gondwanidium Plantianum* (pl. 1, fig. 2), is part of a bipinnate frond with some lobate pinnules.

Walkom (1934) described plant fossils, assigned by Dun (1905) to *Aneimites ovata* (McCoy) Arber, as *Rhacopteris ovata* (McCoy) Walkom. He disagreed with Walton's (1926) inclusion of Australian specimens in *Rhacopteris circularis.* Frenguelli (1941, p. 464 ff) and Archangelsky and Arrondo (1966) also discussed *Rhacopteris ovata.*

It is not possible to see the interveinal fibres in Archangelsky and Arrondo's figure (1966, pl. III, fig. 1) of McCoy's type specimen L6. However, Mr. N. Hughes (pers. comm.) kindly re-examined the specimen and confirmed their presence.

A number of South American specimens, figured as *Rhacopteris ovata,* show fine interveinal lineations. Steinmann (1929) indicated them clearly on his hand-drawn text figure 29C. Frenguelli (1943, pl. 1) figured very large pinnae that appear to have many fine lineations, but no coarse veins, although there are apparent "folds" in the leaf blade. Another figured specimen (pl. 4, fig. 2) apparently has three or four fine interveinal lineations around the margin of the upper pinna. The illustration of Jongmans (1954, pl. 25, fig. 36) also shows the fine lineations clearly.

Pinnae figured by Walkom (1934, pl. 18, figs 3a, 3b) as ? *Noeggerathia* sp. have fine lineations between the veins, and thus belong to *Pseudorhacopteris.* The pinnae are more broadly ovate-flabelliform than those in the type specimen, possess a non-crenulate margin, and so may not be conspecific.

Distribution:— Queensland— ?Clarke River Formation. New South Wales—"Upper Kuttung Series", many localities near Stroud, Paterson, Port Stephens, and Currabubula. Argentina—"Paganzo I" of La Rioja (Frenguelli, 1943, 1946; Archangelsky and Arrondo 1966). Peru—Ambo Group, Huanuco and Carhuamayo (Steinmann, 1929; Frenguelli, 1943; Jongmans, 1954), and Paracas Peninsula (Read, 1938; Jongmans, 1954). Kashmir—Po Series near Thabo (Gothan and Sahni, 1937).

SPECIES ASSOCIATED WITH *PSEUDORHACOPTERIS* IN AUSTRALIA

Genus ADIANTITES Goeppert, 1836

Type Species:— *Adiantites oblongifolium* (Brongniart) Goeppert, 1836.

Adiantites paracasica Gothan, 1928

1922 *Palmatopteris furcata,* in Berry, pp. 15-17, pl. 1, figs 1-3.
1922 *Sphenopteris* sp., in Seward, pp. 279-280, pl. 1, figs 1-2.
1928 *Sphenopteris paracasica* Gothan, p. 293, pl. 13, fig. 1.
1929 *Sphenopteris paracasica,* in Steinmann, p. 32, fig. 30.
1935 *Sphenopteris furcata,* in Oliveira, pp. 310-311, pl. 3, figs 1, 7, 9, 11, 12; pl. 4, figs 6, 8 10.
1938 *Sphenopteris paracasica,* in Read, p. 399, fig. 2.
1954 *Adiantites gothanica* Dolianiti, pp. 11-16, pl. I-II.
1958 *Diplothmema* sp. ?, in M. White (unpubl.), pl. 3, fig. 6.
1965 *Eremopteris australis* M. White, pl. 3, figs 4, 5; pl. 4, fig. 1.

Discussion:— Material forming the basis of *Eremopteris australis,* the *nomen nudum* of M. White (1965), is identical with some of the smaller pinnae listed in the above synonymy, such as *Sphenopteris paracasica* in Read (1938).

Distribution:— Queensland—Clarke River Formation. Peru—Paracas Peninsula (Berry, 1922; Seward, 1922; Gothan, 1928; Steinmann, 1929; Read, 1938). Brazil—Poti Formation, Teresina (Oliveira, 1935; Dolianiti, 1954).

Genus SPHENOPTERIDIUM Schimper, 1874

Type Species:— *Sphenopteridium dissectum* (Goeppert) Schimper, 1847.

? Sphenopteridium intermedium (Feistmantel) comb. nov.
Pl. 3, figs 10, 11, 12A

1878 *Rhacopteris internedia* Feistmantel, p. 75, pl. 2, fig. 2.
1879a *Rhacopteris septentrionalis* Feistmantel, pp. 147-148, pl. 22, fig. 5.
1879a *Archaeopteris Wilkinsoni* Feistmantel, pp. 148-149, pl. 24, fig. 4; pl. 25, fig. 1.
1883 *Archaeopteris Wilkinsoni,* in Tenison—Woods, p. 97.
1883 *Rhacopteris internedia,* in Tenison—Woods, p. 98.
1883 *Rhacopteris septentrionalis,* in Tenison—Woods, p. 98.
1890 *Archaeopteris Wilkinsoni,* in Feistmantel, p. 96, pl. 10, figs 1, 2.
1890 *Rhacopteris septentrionalis,* in Feistmantel, p. 100, pl. 3, fig. 5.
1890 *Rhacopteris internedia,* in Feistmantel, p. 99, pl. 6, fig. 3.
1905 *Rhacopteris internedia,* in Dun, p. 160, pl. 22, figs 2, 3.
1934 ?*Sphenopteridium cuneatum* Walkom, pp. 432-433, pl. 18, fig. 2.
1938 *Rhacopteris* sp. cf. R. *cuneata,* in Read, pp. 401-402, fig. 5.

Doubtful records
1879a *Archaeopteris* sp., in Feistmantel, p. 148, pl. 22, fig. 4.
1890 *Archaeopteris* sp., in Feistmantel, pl. 10, fig. 3.
1954 *Rhacopteris* cf. *cuneata,* in Jongmans, pp. 207-208, pl. 20, fig. 18.

Diagnosis:— Rachis ribbed, pinnules alternate, pinnae bases constricted, venation dichotomizing, no midribs. Two or three alternate pinnae in each pinnule, formed of strongly dissected segments; ultimate segments with a single vein; fused lower parts of segments contain more than one vein.

Type Specimen:— Feistmantel's original specimen from Port Stephens, New South Wales, is lost (Pickett, pers. comm.). The neotype, nominated and figured herein, AMF35619, is from Paterson, New South Wales. Dun (1905, pl. 22, fig. 2), who examined Feistmantel's type, previously identified the neotype as *Rhacopteris intermedia.*

Discussion:— Three of Feistmantel's species are combined here. Of these, *Rhacopteris intermedia* Feistmantel (1878) has nomenclatural priority, but unfortunately his sole example is lost. *Rhacopteris septentrionalis* Feistmantel (1879a), is based on a single, heavily iron-stained specimen (AMF35620, refigured here as pl. 3, fig. 10), which is difficult to observe. The slab with a syntype of *Archaeopteris Wilkinsonii* Feistmantel (AMF35617, figured here as pl. 3, fig. 11A), also bears a number of pinnule fragments not shown in Feistmantel's figures. Pinnules shown on AMF35617 (pl. 3, fig. 11B) lie flat on the one plane. Those on specimen AMF35619 (pl. 3, fig. 12A), may have been enrolled and lain at an angle to the plane of the rachis.

This species has been included tentatively in *Sphenopteridium,* as it has deeply dissected pinnae. Those of the genus *Aphlebia,* (e.g. *Aphelbia* sp. figured by Halle (1927, pl. 32, figs 3, 4)), are similar, but the rachis is slender and fern-like in the Australian specimens. Fragments from Peru figured as "Aphlebien davon" by Steinmann (1929, fig. 29D, E) are too small for comparison with the Australian material.

Distribution:— New South Wales—"Upper Kuttung Series" at Paterson, Port Stephens, Stroud, and Currabubula. Peru—Paracas Peninsula (Read, 1938).

[*Cyclopteris*] sp.
Pl. 3, figs 8, 9

1899 *Cardiopteris* cf. *polymorpha,* in Dun, pp. 107-108, pl. 15.

Discussion:— Two of Dun's (1899) specimens are refigured here to show the variation in shape of the pinnae (pl. 3, figs 8-9). These pinnae very closely resemble isolated ones of *Angaropteridium cardiopteroides* (Schmalhausen) Zalessky (see Neuburg (1948, pls 34-35) and Rasskazova (1962, pls 9-13)), but the latter has more strongly differentiated, coarser venation near the pinna base. As so little is known of the Australian specimens, they should not be placed in *Angaropteridium.*

The generic identity of the present material is uncertain. Wolfe (1962) proposed *Fryopsis* for *Cardiopteris* Schimper *non* Royle, but Daber and Kahlert (1969) stated that *Cardiopteris* is not separable from *Cyclopteris.* [*Cyclopteris*] sp. has pinnae closely resembling those of fragments identified by Walkom (1934, p. 432, pl. 18, fig. 1) as *Cardiopteris* cf. *frondosa.* Comparable pinnae attached to short lengths of rachis figured as *Adiantites* (?) *robustus* Walkom (1934 p. 433, pl. 18, fig. 4) possibly represent foliage of the same species.

Specimens figured by M. White (1964, p.5; 1969a, p. 98) as *Cardiopteris polymorpha* are now included in *Gondwanidium Plantianum.*

Distribution:— New South Wales—"Upper Kuttung Series", at Paterson.

Genus CYCLOSTIGMA Haughton, 1860

Type species:— *Cyclostigma kiltorkense* Haughton, 1860.

Cyclostigma aegyptiaca Jongmans, 1955

1940 *Cyclostigma aegyptiaca* Jongmans, p. 227, pl. 3, fig. 5a-c.
1955 *"Cyclostigma" aegyptiaca,* in Jongmans, p. 68-69, pl. 10, figs 7, 8a-b; pl. 11, fig. 8c-h.
1958 *Stigmaria ficoides,* in M. White (unpubl.), pl. 2, fig. 5.
1965 *Stigmaria ficoides,* in M. White, pl. 3, fig. 1.

Discussion:— Vasculation in the scars of White's *Stigmaria ficoides* is asymmetrical, indicating that they are leaf scars, not root scars; hence *Stigmaria,* a genus based on roots, is inappropriate.

Distribution:— Queensland—Clarke River Formation. Egypt—"Upper Sandstone" of Sinai (Jongmans, 1955).

LYCOPOD incertae sedis

"Lepidodendron Veltheimii Sternberg, 1828"

Discussion:— I have not seen the specimens M. White (1965, pp. 159-160) identified under this name. Leaf cushions of better preserved specimens of *"Lepidodendron Veltheimii"* in the collections of the Geological Survey of Queensland lack evidence for the presence of a ligule and parichnos. The specimens may represent a new species of *Sublepidodendron,* but their preservation makes them unsuitable as the basis of a new taxon.

Distribution:— Queensland—Clarke River Formation. New South Wales—(?) Rouchel Brook.

Genus CALAMITES Brongniart, 1828

Type Species:— *Calamites radiatus* Brongniart, 1828.

Calamites peruvianus Gothan, 1928

Discussion:— Feistmantel (1879a, 1890) and M. White (1965) identified specimens from Stroud, New South Wales and from the Clarke River area of northern Queensland respectively, as *Calamites radiatus.* Both authors may have been dealing with specimens of *C. peruvianus.* I have identified *C. peruvianus* in collections from the Stroud District of New South Wales.

Bornia radiata figured by de Koninck (1898, pl. 7, fig. 1) may also be *C. peruvianus,* but its locality is unknown.

Two specimens from Egypt, identified by Jongmans (1955, pl. 13) as *Asterocalamities scrobiculatus,* have non-alternating ribs as nodes (figs 13, 14), although the specimen of fig. 12 has distinct irregularities in the apposition of the ribs. These irregularities resemble those exhibited by some representatives of *Calamities peruvianus* from Peru (see Berry (1922, pls 5-7), Gothan (1928, pl. 14, fig. 1) and Steinmann (1929, fig. 28)). I suspect that material identified as *Asterocalamites* may only be variants of *Calamites.* Kräusel (1931, p. 531) summed up the relationships of *C. peruvianus* as "extremely unclear as long as leaves and fructifications are unknown". Fructifications are still unknown, and the only foliage from strata of comparable age, ? *Asterophyllites* sp. figured by Høeg, Bose and Shukla (1957, pl. 2, figs 21, 22), does not occur near known occurrences of *Calamites peruvianus.*

Distribution:— Queensland—Clarke River Formation. New South Wales—Smith's Creek, near Stroud. Peru—Paracas Peninsula (Read, 1938). Colombia—Gachala Series, Gachalá (Kräusel, 1931). Argentina—"Paganzo I", La Rioja (Frenguelli, 1943). Egypt—"Upper Sandstone", Ayun Musa, Sinai, (Jongmans, 1955).

Genus GONDWANIDIUM Gothan, 1927

Type species:— *Gondwanidium validum* (Feistmantel) Gothan, a junior synonym of *Gondwanidium Plantianum* (Carruthers) Gerth.

Gondwanidium Plantianum (Carruthers) Gerth, 1932
Pl. 1, fig. 2; pl. 2, fig. 3

1869 *Odontopteris Plantiana* Carruthers, p. 155, pl. 6, figs 2, 3.
1876 *Neuropteris valida* Feistmantel, p. 75.
1879a *Neuropteris valida* Feistmantel, p. 10.
1879b *Neuropteris (Neuropteridium) valida* Feistmantel, pl. II-VI.
1888 *Aneimites austrina* Etheridge Jr, p. 1304, pl. XXXVII.
1895 *Neuropteridium validum,* in Kurtz, p. 127, pl. 1, figs 1, 2.
1903 *Neuropteridium validum,* in Seward, p. 85, pl. X, figs 1, 1a, 1b, 2.
1904 *Rhacopteris inaequilatera,* in Stirling, pl. 1, figs 1-5.
1905 *Neuropteridium validum,* in Arber, p. 116, pl. VI, fig. 1, text fig. 28.
1908 *Neuropteridium plantianum,* in White, p. 486-7.
1919 *Neuropteridium Plantianum,* in Lundqvist, p. 16, pl. 1, figs 17, 18.
1921 *Neuropteridium validum,* in Kurtz, p. 150, pl. I, figs 1, 2; pl. VIII, figs A-A3, 89.
1921 *Neuropteridium validum* var. *argentina* Kurtz, p. 151, pl. VIII, figs 83a-88; pl. XV, fig. 143.
1927 *Gondwanidium (Neuropteridium) validum* var. *argentina,* in Gothan, p. 342.
1932 *Gondwanidium plantianum* (Carruthers) Gerth, p. 172.
1944 *Gondwanidium Plantianum,* in Frenguelli, pl. IX, figs 1, (?) 2, 3.
1946 *Gondwanidium Plantianum,* in Frenguelli, pl. V, figs 2, 3.
1948 *Neuropteridium (Gondwanidium) validum,* in Teixeira, p. 73, pl. I, figs 1-4.
1953 *Gondwanidium Plantianum,* in Dolianiti, p. 127, figs 1, 2.
1964 *Aneimites austrina,* in Hill and Woods, pl. CXV, figs 1, 2.
1964 *Gondwanidium validum,* in Balme, p. 82.
1964 *Rhacopteris meridionalis,* in M. White, pl. 5, fig. 1.
1964 *Cardiopteris polymorpha,* in M. White, p. 5, figs 2, 3.
1969a *Cardiopteris polymorpha,* in M. White, p. 98, pl. A; pl. B. fig. 1.

Additional references to occurrences of *Gondwanidium* in Argentina and India have been made by Fossa-Mancini (1940) and Maithy (1965), respectively.

Diagnosis:— Frond imparipinnate, rachis bearing sessile or slightly petiolate, lobate or simple, alternately inserted pinnae, sometimes pinnatifid towards centre of frond. Venation of expanded segments radiating, dichotomizing, slightly arched, primary venation absent. Cuticular data and reproductive structures unknown.

Type Specimen:— V 228, Geology Department, British Museum (Natural History), London (Arber, 1905, p. 117). Locality—Coal measures of Rio Grande do Sul, Brazil. Figured by Carruthers (1869, pl. VI).

Discussion:— As discussed in the section *Pseudorhacopteris,* Arber (1902) incorrectly united *Aneimites austrina* Etheridge Jr with *Otopteris ovata* McCoy. The rock slab incorporating the holotype of *Aneimites austrina* Etheridge Jr (1888) (GSQF11983; refigured pl. 1, fig. 2) also bears a much better preserved fragment from a second frond, GSQF11984. The latter was figured in Hill and Woods (1964, pl. CXV, fig. 2), and is refigured here (pl. 2, fig. 3). Specimens GSQF11983 and GSQF11984 were formerly catalogued under the number GSQF1650.

Zeiller (1895, p. 616) united *Odontopteris Plantiana* Carruthers from Brazil with *Neuropteridium validum* Feistmantel from India. However, Maithy (1965, p. 244) considered that the South American and the Indian forms represented distinct species, and also defined a second Indian species, *Gondwanidium indicum,* on cuticular characteristics. Distinctions used by Maithy are not adequate to separate the Indian *G. validum* from South American *G. Plantianum,* because of great variability of form that occurs in individual fronds. This variability is shown in some of the specimens figured by Kurtz (1921, e.g. pl. VIII, figs A, 85a 87 and A3).

The Angara (central Siberian) species referred to *Gondwanidium* have distinct midribs in the pinnae (Meyen, 1967). They belong in *Paragondwanidium* Meyen (1969, p. 145).

Distribution:— New South Wales—Seaham Formation. Queensland—Joe Joe Formation; Silver Valley Conglomerate. Western Australia—Wagina Sandstone (Balme, 1964). Transvaal—Middle Ecca Series (Seward, 1903). Angola—Lutôe Series (Teixeira, 1948; Real, 1958). India—Talchir Series (Feistmantel, 1876, 1879a, 1879b). Argentina—La Rioja, San Luis—"Paganzo II" (Kurtz, 1921; Cuerda *et al.*, 1968). Brazil—Rio Grand do Sul—Tubarão Group (Carruthers, 1869; Lundqvist, 1919; Dolianiti, 1953).

These occurrences are Upper Carboniferous to Lower Permian, except for the single fragment reported by Balme (1964) from the Upper Permian of Western Australia.

STRATIGRAPHIC DISCUSSION

Walkom (1920, p. 284) divided the Carboniferous floras of the Lower Hunter Valley, New South Wales, into a lower, or *"Lepidodendron"* Flora, and an upper, or *"Rhacopteris"*—rich Flora. *"Lepidodendron"* occurs in the lower part of the Italia Road formation and in older units, whereas it is replaced by *"Aneimites"*(equivalent to *Gondwanidium* here) in the upper part of that Formation (Rattigan, 1967). This coincides closely with the Westphalian-Stephanian boundary indicated by Banks *et al.* (1969 opposite p. 472). Helby (1970, fig. 3) also shows a break in the palynological succession near the top of the Italia Road Formation. Walkom's two floras are named here the Pseudorhacopteris Flora and the Gondwanidium Flora.

Pseudorhacopteris Flora

'The diagnostic genera of this flora are *"Lepidodendron"* and *Pseudorhacopteris.* The base of the Pseudorhacopteris Flora is the first appearance of *Pseudorhacopteris ovata.* In New South Wales the range of the Flora is Namurian-Westphalian (Table 1). Upper Devonian-Lower Carboniferous floras with *Leptophloeum australe* predate the Pseudorhacopteris Flora. Late Carboniferous or early Permian specimens of *"Rhacopteris"* and *"Cardiopteris",* from the lower part of the Youlambie Conglomerate, Queensland, and near to or at the top of the Seaham Formation, New South Wales (Runnegar, 1969, fig. 1), are now identified as *Gondwanidium Plantianum.*

The Pseudorhacopteris Flora is thought to be typical of the Gondwana province. Provincialism in pre-Permian floras is supported by Lee (1964, p. 102), who considered that an endemic botanical province began to develop in China during the Upper Devonian.

Pseudorhacopteris Flora in New South Wales.

Details of occurrences of this Flora in New South Wales are given in the sections on *Pseudorhacopteris ovata, ? Sphenopteridium intermedium,* [*Cyclopteris*] sp. *Calamites peruvianus,* and *"Lepidodendron Veltheimii".* Reports of *Rhacopteris* from the "Kullatine Series", 10 miles west of Kempsey, New South Wales (Viosey, 1934, p. 337); at Kew, New South Wales, just below a glacial horizon (Voisey, 1939, p. 260); from near Voisey's Kempsey locality and elsewhere in the same district, immediately below strata dated as Namurian E by marine invertebrates (Campbell, 1962, p. 39); and by Campbell (1969, figs. 4-5), also represent occurrences of the Pseudorhacopteris Flora.

Pseudorhacopteris Flora in Queensland.

According to D. A. White (1965, p. 61) the Clarke River Formation of Northern Queensland contains Devonian or Lower Carboniferous marine faunas near its base. The marine sediments pass upwards into non-marine rocks containing plants which M. White (1965, p. 160) dated as Lower Carboniferous, and the Formation is overlain by post-Palaeozoic rocks. Floral lists given by M. White (1965, pp. 159-160) are amended below with redeterminations indicated*.

Locality BRS 28—*Lepidodendron* cf. *L. Veltheimii* Sternberg.
Locality BRS 29—stems and wood, **Calamites peruvianus* Gothan, *Lepidodendron* cf. *L. Veltheimii* Sternberg.
Locality 2273—Lepidodendroid stems, **Cyclostigma aegyptiaca* Jongmans.
Locality 2303—fern stems, *Lepidodendron Veltheimii* Sternberg, *Sigillaria* sp.
Locality BRS 64—**Calamites peruvianus* Gothan, ribbon-like stems, leaves etc., **Adiantites paracasica* Gothan.
Locality BRS 65—**Calamites peruvianus* Gothan.
Locality BRS 66—**Calamites peruvianus* Gothan, **Pseudorhacopteris ovata* (McCoy) Rigby.
Locality BRS 67—**Calamites peruvianus* Gothan, **Pseudorhacopteris ovata* (McCoy) Rigby.

TABLE 1

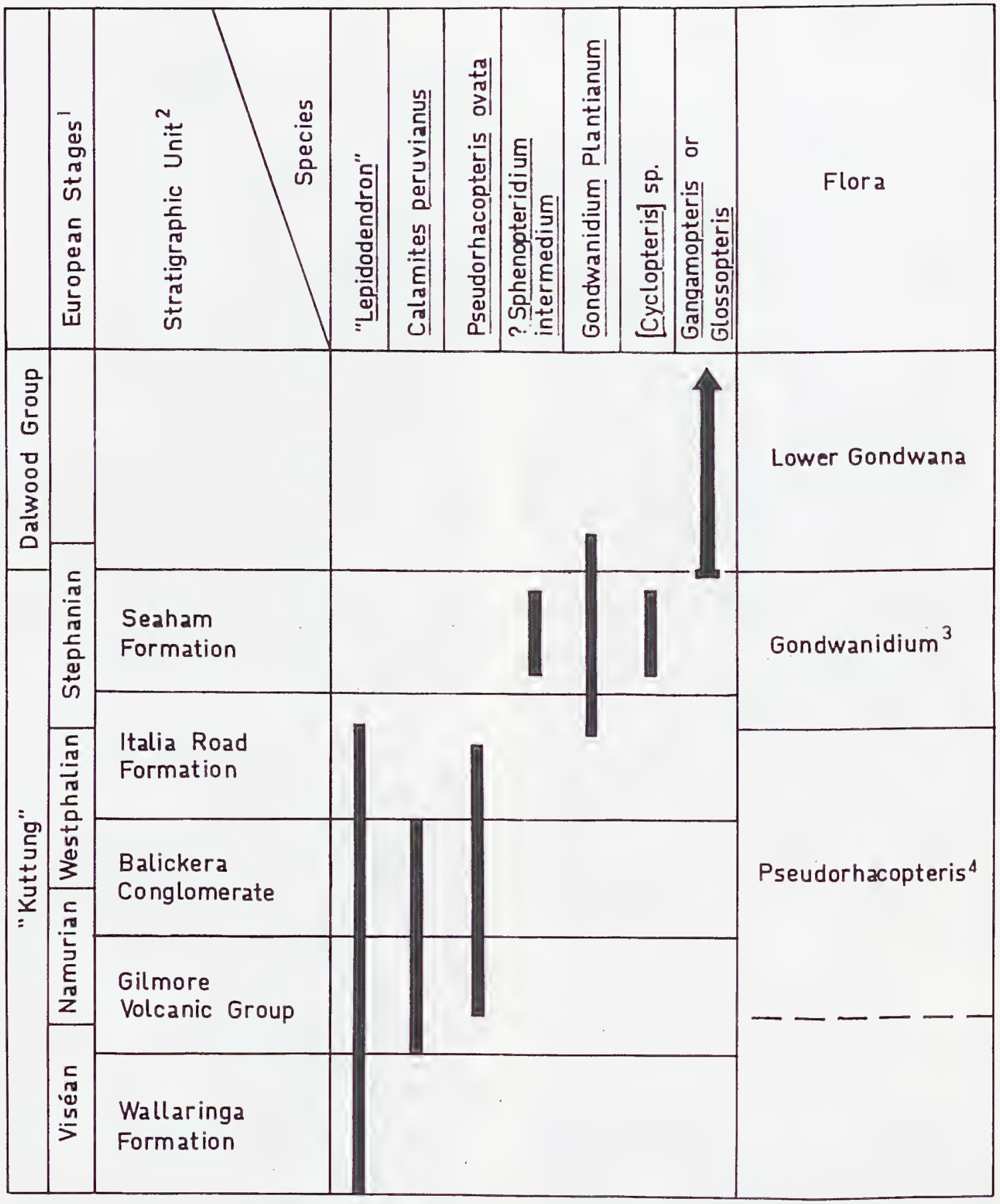

Table 1. Distribution of some significant Upper Carboniferous plants in the Lower Hunter District of New South Wales. Arrowhead indicates species range higher.

1. After Banks *et al.* (1969).
2. Succession discussed by Rattigan (1967).
3. Westphalian-Stephanian boundary and Pseudorhacopteris Flora-Gondwanidium Flora boundary may or may not coincide.
4. Base of Pseudorhacopteris Flora is defined by first appearance of *Pseudorhacopteris ovata.*

As now interpreted, the flora of the Clarke River Formation comprises *"Lepidodendron Veltheimii* Sternberg", *Sigillaria* sp., *Cyclostigma aegyptiaca* Jongmans, *Calamites peruvianus* Gothan, *Adiantites paracasica* Gothan, *Pseudorhacopteris ovata* (McCoy) Rigby, and other inderterminate remains. This is a typical Pseudorhacopteris Flora, which in New South Wales (table 1) is Namurian-Westphalian in age.

The flora of the Pascoe River Beds described by M. White (1969b) contains species that I have identified as *Cyclostigma aegyptiaca* Jongmans and [*Cyclopteris*] sp. This is also a Pseudorhacopteris Flora.

Pseudorhacopteris Flora in South America

On Paracas Peninsula, Peru, coal measures with the Pseudorhacopteris Flora crop out as isolated outliers than cannot be readily related stratigraphically to other sediments. Lycopod stems from these rocks, identified by Zeiller (in Lisson, 1917, pp. 20-21) with two Westphalian species of *Lepidodendron,* influenced Berry (1922, p. 11) to suggest a Westphalian age for the flora. Gothan (1928, pp. 294-295) combined both species into *Lepidodendron peruvianum,* and Jongmans (1954, pp. 206-207) recombined this as *Lepidodendropsis peruvianus.* Jongmans attributed a Lower Carboniferous age to the flora as it contained *Lepidodendropsis.* I disagree with Jongmans' generic assignment. The scar arrangement is Lepidodendroid, but the appropriate scar ornamentation, ligule pit, and parichnos have not been observed. Thus the coal measures of Paracas Peninsula are not necessarily pre-Namurian. The Paracas species differes from the Australian "*Lepidodendron Veltheimii*".

Coal measures with the Pseudorhacopteris Flora in the Ambo Group of inland Peru are usually regarded as Lower Carboniferous in age, but Steinmann (1911, p. 51) pointed out that associated marine faunas are Upper Carboniferous. The Ambo Group in Peru disconformably overlies Middle Devonian or older rocks (Newell *et al.*, 1953, p. 9), and in Bolivia disconformably overlies Middle or Upper Devonian (Salomon Rivas, 1968). The Tarma Group, which has upper Carboniferous marine fossils (Newell *et al.*, 1953, p. 12), disconformably overlies the Ambo Group. This evidence is consistent with the Westphalian-Stephanian age assigned to the Ambo Group by Schlatter and Nederlof (1966, pl. II).

In Argentina, Menéndez (1965) dated a microflora from a bed with *"Rhacopteris ovata"* from La Rioja as Westphalian. Menéndez (1969, p. 525) also stated that a marine fauna with an associated flora containing *"Rhacopteris ovata"* from San Juan, Argentina is Westphalian.

Amos (1969, p. 60), on marine faunal evidence, considered that the Carboniferous section, near Upsallata, Mendoza, Argentina was probably Upper Carboniferous in age. The flora of the lower unit, the Tramojo Series, contains a Pseudorhacopteris Flora, and the Westphalian age advocated by Menéndez (1969) is supported.

Pseudorhacopteris Flora in Africa

Carboniferous plants from Egypt (Sinai), discussed by Rigby (1970), represent the Pseudorhacopteris Flora. Specimens of *"Rhacopteris"* reported by Boureau (1954) from Aïr, Niger, also belong to a Gondwanaland flora, but their generic identification is uncertain. According to Horst (1962) Gondwanaland extended far to the north of Niger, to northern Algeria in the Permian, and to Tunisia in the Triassic (Halstead, 1972).

Gondwanidium Flora

The base of this flora is defined by the first appearance of *Gondwanidium,* which also marks the upper limit of the Pseudorhacopteris Flora. *Gondwanidium Plantianum* is closely associated with glacigene sediments and its appearance may be indicative of climatic change. *Gondwanidium* co-existed for a time with the succeeding Lower Gondwana or Glossopteris Flora (Table 1). The base of the Glossopteris Flora, marked by the incoming of *Glossopteris* and *Gangamopteris,* is regarded as the beginning of the Permian in eastern Australia by Banks *et al.* (1969, p. 476).

Following discussions with Mr. B. Engel, University of Newcastle, New South Wales, concerning my proposal of a Carboniferous age for the Markwell Coal Measures (Rigby, 1969), I re-examined the plants involved and realise that my original conclusion was incorrect. These specimens belong in *Gondwanidium Plantianum.* Mr. Engel informs me that *Glossopteris* occurs at the same locality. The Markwell Coal Measures belong low in the Permian, probably much lower than the Greta Coal Measures, where *Gondwanidium* is absent.

Gondwanidium Plantianum occurs near Newcastle, New South Wales, in the Seaham Formation. Helby (1970) advocated a Permian age for this formation on palynological grounds.

Very few species are known from the flora of the Joe Joe Formation of central Queensland. Shell (1952, p. 25) listed Floral determinations by Sahni and Walkom as *Dadoxylon,* ? *Gangamopteris* sp., *Gangamopteris cyclopteroides* Feistmantel, *Glossopteris, ? Schizoneura* sp., ? *Gondwanidium* or ? *Neuropteridium* or *Aneimites.* A flora from the base of the "Colinlea Series" was given (p. 26) as *Dadoxylon* sp., ? *Gondwanidium validum,* ? *Neuropteridium* sp. or ? *Aneimites* sp. M. White (1964, p. 5) identified *Rhacopteris meridionalis* Feistmantel, *Cardiopteris polymorpha* Goeppert, and "intermediate type pinnules" from the Joe Joe Formation. Subsequently the *Rhacopteris* specimens were re-identified as *Cardiopteris polymorpha* (M. White, 1969a, p. 98). I have examined her specimens and regard all as examples of *Gondwanidium Plantianum.* Thus, the flora of the Joe Joe Formation comprises *Dadoxylon* sp., ? *Gangamopteris* sp., *Gangamopteris cyclopteroides* Feistmantel, *Glossopteris* sp., *Paracalamites* sp. (=*Schizoneura* sp. of Shell (1952)), *Gondwanidium* sp., and *Gondwanidium Plantianum* (Carruthers) Gerth. The Joe Joe Formation is at least partly lower Permian, because of the presence of *Gangamopteris* reported by Shell (1952). Evans (1969) considered the Joe Joe Formation, central Queensland, to be partly equivalent to the Seaham Formation, and

partly younger, on the basis of their similar assemblages of miospores and the absence of striate disaccate pollen.

Stirling (1904) identified plant fossils from the Silver Valley Conglomerate, north Queensland, as *Rhacopteris inaequilatera, Calamites,* and *Cardiopteridium.* From an examination of his figures, I consider the *Rhacopteris* specimens (pl. 1) to be *Gondwanidium Plantianum.* A minimum Upper Carboniferous age for the Silver Vallery Conglomerate is implied by the 292-315 m.y. radio-metric age of Elizabeth Creek Granite (Richards *et al.,* 1966, p. 26). This granite intrudes the Glen Gordon Volcanics, which probably conformably overlie the Silver Valley Conglomerate (Blake, 1968, p. 26).

"Rhacopteris ovata" reported by Gulline (1967) from the Wynyard Tillite may also be *G. Plantianum,* but I have not seen the material.

In India, *Gondwanidium* is restricted to the Karharbari Stage, the upper or post-glacial part of the Talchir Series (Surange, 1966, chart 8). All Indian occurrences are Lower Permian. Similarly in Brazil, *Gondwanidium* is known only from the immediately post-glacial part of the Guatá Subgroup of the Tubarão Group (Rigby, 1972, table 1). In Argentina, *Gondwanidium* occurs in the lower part of the Lower Permian section of the Paganzo Basin (Archangelsky, 1967, table 1; Cuerda *et al.*, 1968).

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EXPLANATION OF PLATE 1

Figure 1 *Pseudorhacopteris ovata* (McCoy) Rigby comb. nov. AMF17497, Kuttung "Series", Sugarloaf Creek, Stroud, New South Wales. Shows expanded and expanding pinnae arranged along the unbranched rachis.

Figure 2 *Gondwanidium Plantianum* (Carruthers) Gerth. GSQF11983, Joe Joe Formation, near Mount Mudge, Drummond Range, Queensland. Preservation is very poor with venation obliterated. The specimen figured as pl. 2, fig. 3 from the same rock slab shows venation clearly.

PLATE 1

EXPLANATION OF PLATE 2

Figure 3 *Gondwanidium Plantianum* (Carruthers) Gerth. GSQF11984, x2, Joe Joe Formation, near Mount Mudge, Drummond Range, Queensland. Shows dichotomising pinna venation, and the absence of a definite midrib.

Figures 4-6 *Pseudorhacopteris ovata* (McCoy) Rigby comb. nov. AMF17497, holotype, Kuttung "Series", Sugarloaf Creek, Stroud, New South Wales. Various fragments enlarged to show additional details. 4, frond apex, x4, to show folding of pinna tips and juvenile pinnae expansion, interveinal fibres are poorly developed. 5, leaf margin from expanded pinna along margin shown as the base of fig. 6, x 10. Vein-like markings are fibres. The marks—indicate the position of veins. 6, pinnule from right side of holotype, about one-third of its length from the base, x4. Veins show poorly as ribs near the lower margin and grooves towards the upper part of the figure. Lineations are fibres.

Figure 7 Frond fragments cf. *Pseudorhacopteris ovata* (McCoy) Rigby comb. nov. AMF35618 part, x4, Smith's Creek, near Stroud, New South Wales. This fragment originally interpreted as a pinnule of *Archaeopteris Wilkinsoni*.

3

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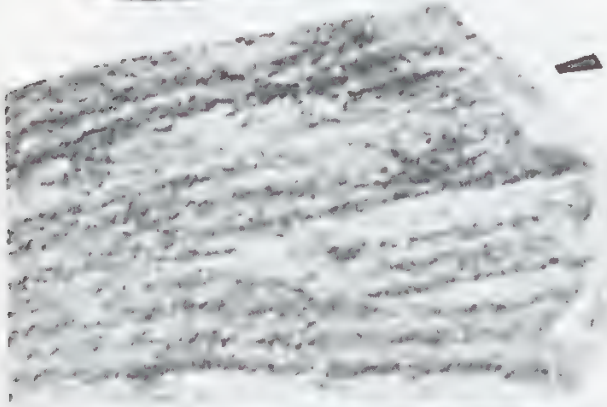

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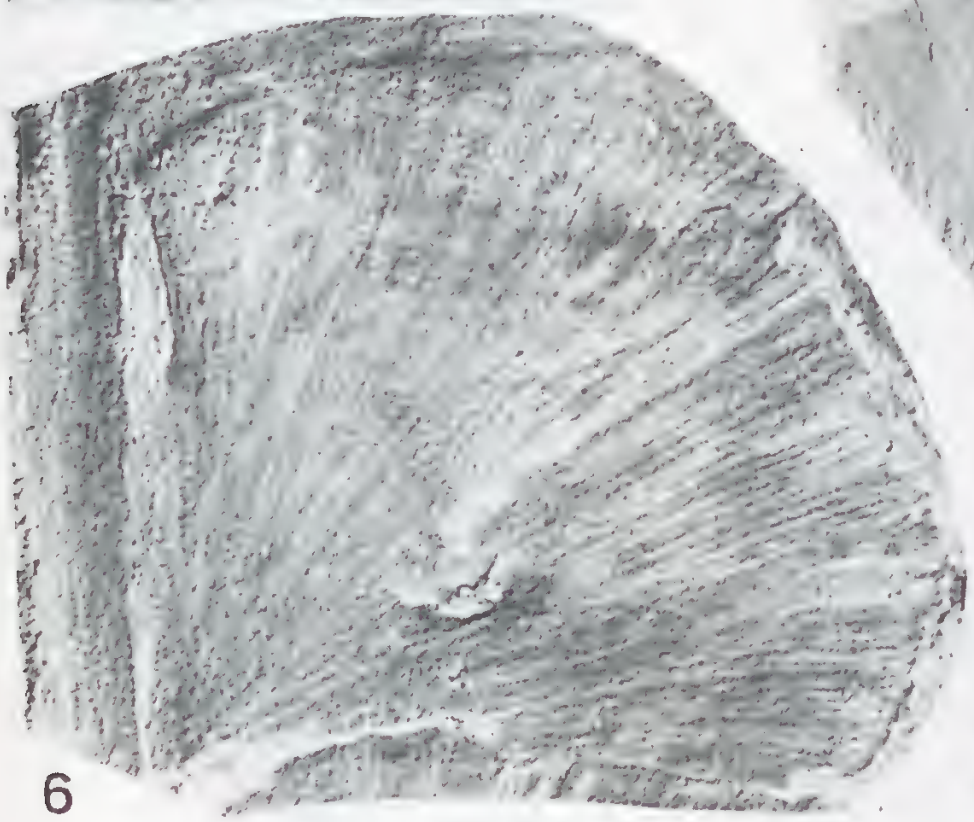

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PLATE 2

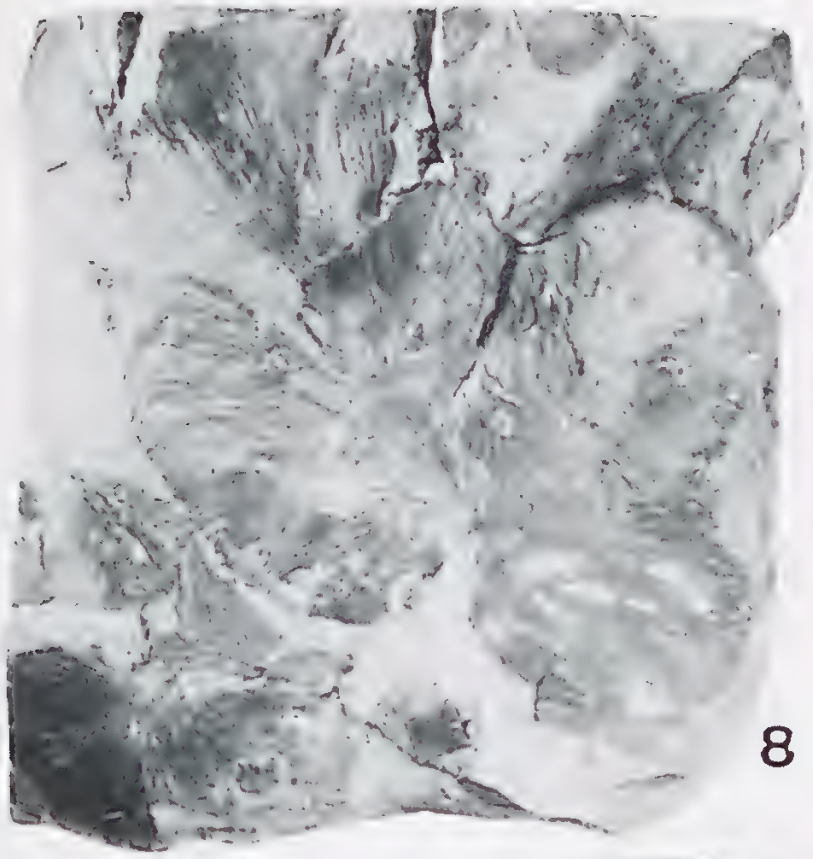
EXPLANATION OF PLATE 3

(All figures except 13 natural size)

Figures 8-9 [*Cyclopteris*] sp., Paterson, N.S.W. 8, AMF35633 showing a large, asymmetrical pinnule. 9, AMF35632 of a small, symmetrical pinnule.

Figures 10-12a ? *Sphenopteridium intermedium* (Feistmantel) Rigby, comb. nov., Smith's Creek, near Stroud, New South Wales. 10, AMF35620, type specimen of *Rhacopteris septentrionalis* Feistmantel. 11, AMF35617; 11a, figured by Feistmantel as *Archaeopteris Wilkinsoni;* 11b, portion of slab not figured previously. 12a, part of specimen AMF35619, neotype of *Rhacopteris intermedia* Feistmantel, originally figured by Dun (1905, pl. 22, fig. 2.).

Figures 12b-13 *Pseudorhacopteris ovata* (McCoy) Rigby comb. nov., AMF35619, Smith's Creek, near Stroud, New South Wales. 12b, fragment of frond. 13, pinna showing faint interveinal fibres, x4.



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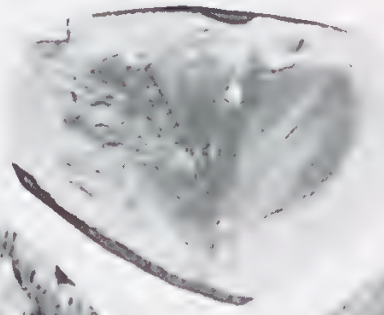

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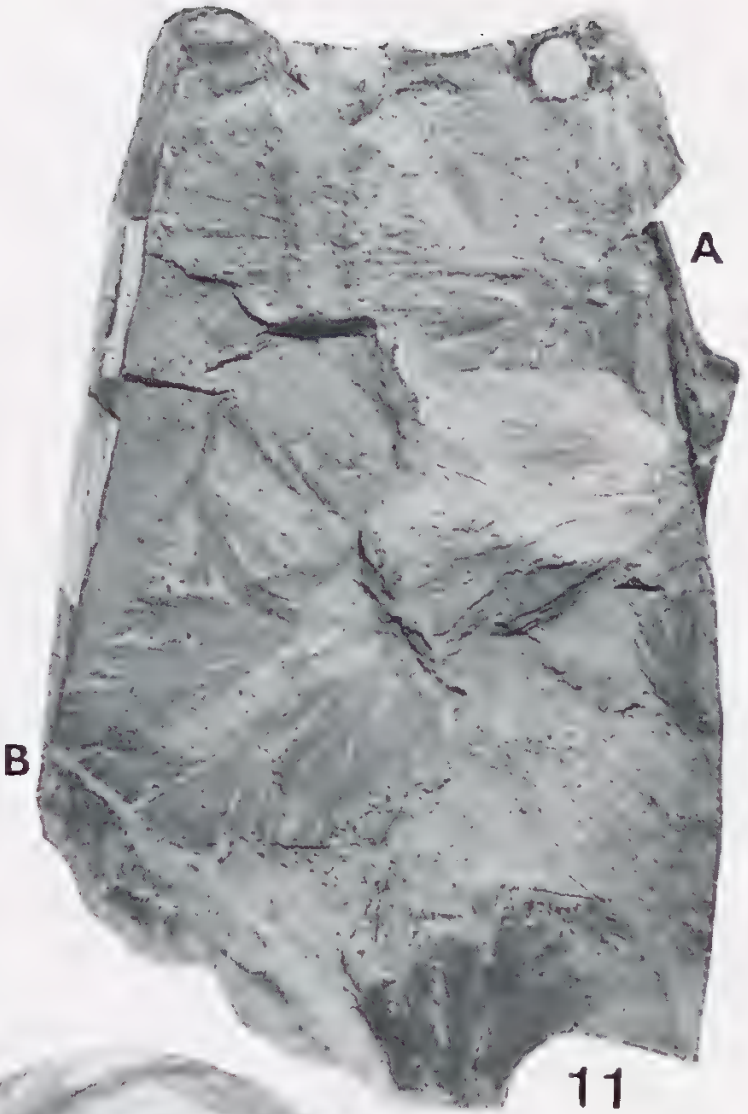

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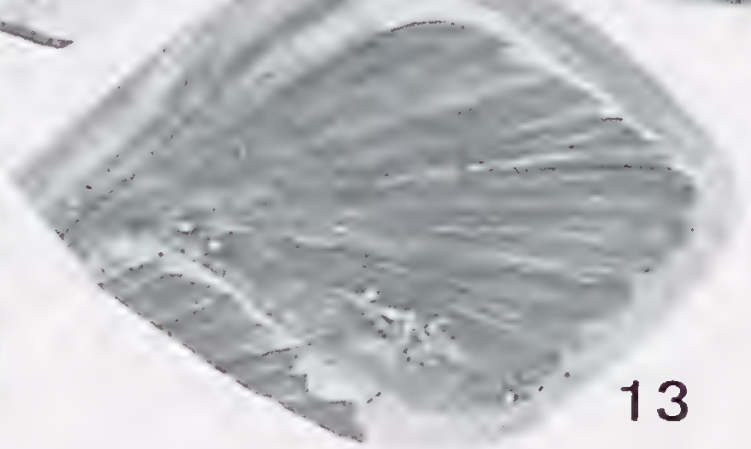

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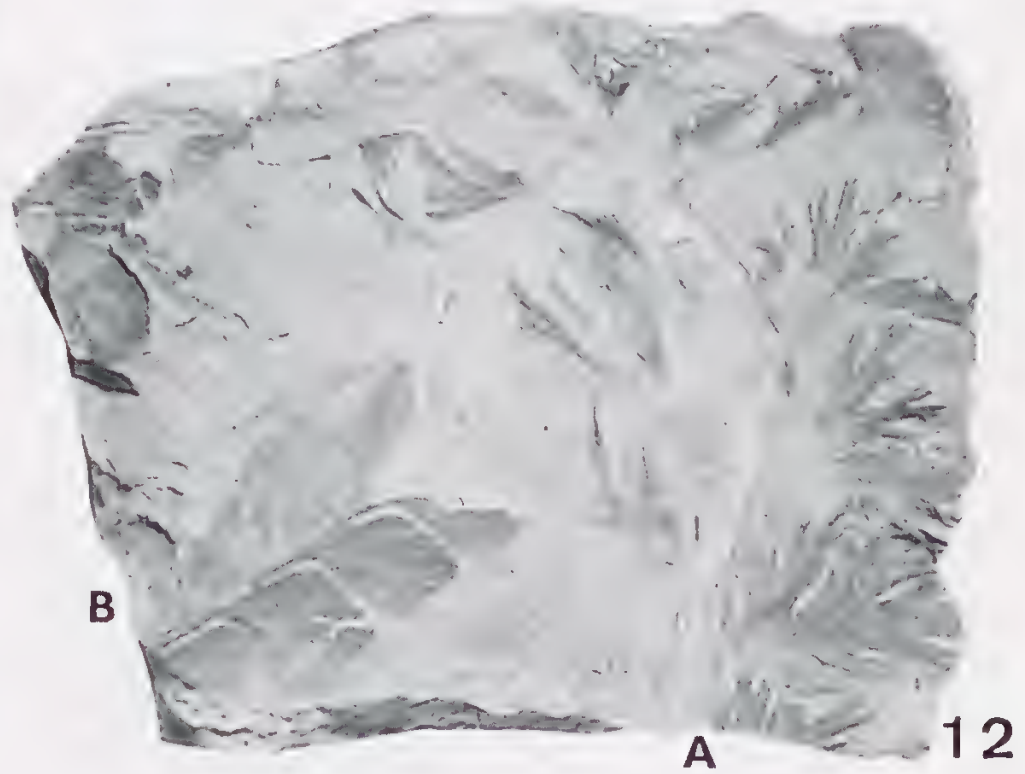

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PLATE 3

QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 351
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EARLY JURASSIC MIOSPORES FROM THE HELIDON SANDSTONE

by
N. J. de JERSEY

BRISBANE
FEBRUARY, 1971

EARLY JURASSIC MIOSPORES FROM THE HELIDON SANDSTONE

by N. J. DE JERSEY
Geological Survey of Queensland

SUMMARY

Miospore assemblages are recorded from shale beds within the Helidon Sandstone, a Jurassic formation in south-eastern Queensland. Additional material has been studied from the overlying Marburg Formation, the underlying Raceview Formation and from the Ripley Road Sandstone, to investigate the biostratigraphic relationships of these units to the Helidon sequence.

From 44 samples examined, 83 distinct species are listed. Two of these are described as new species, and assigned to the genera *Ceratosporites* and *Densosporites*. The genera *Cerebropollenites* and *Zebrasporites* are recorded, for the first time, from Australia. The assemblages from the Helidon Sandstone and Marburg Formation include many species recorded from the Surat Basin, to the west; the investigation has shown that microfloras from the Surat Basin sequence are relatively persistent laterally.

On the basis of material from three stratigraphic holes in the Lowood area, the microfloral sequence in a section of 2400 feet of sediments has been recorded and illustrated by a microfloral distribution chart. Evidence from the microfloras for correlation between the Surat and Moreton Basins is discussed. The lower part of the Helidon Sandstone is regarded as older than the Precipice Sandstone; the remainder of the Helidon Sandstone and the Marburg Formation can be closely related to the Surat Basin succession. Lithological evidence for the lateral extension of the Raceview Formation, below the Helidon Sandstone, is supported by miospore assemblages.

Comparison with European microfloras, dated by marine faunas, indicates that the Helidon Sandstone and Marburg Formation are probably of Liassic age. Assemblages from the type section of the Ripley Road Sandstone, to the east, are of Rhaetic aspect. It is concluded that a continuous conformable sequence of sediments, spanning the Triassic-Jurassic boundary, is preserved in the area to the east of the West Ipswich Structure.

INTRODUCTION

In a recent paper Reiser and Williams (1969) have described the microfloral succession in Lower Jurassic sediments of the Surat Basin. To the east of the Surat Basin, and partly separated from it by the Kumbarilla Arch (Allen and Hogetoorn, 1970, pp. 3, 11) the Moreton Basin of south-eastern Queensland also contains Jurassic sediments. The primary purpose of the present investigation has been to study the microfloral sequence of the Helidon Sandstone, at the base of the Jurassic succession in the Moreton Basin, so that it may be compared and correlated with that of the Surat Basin.

Although the study was based primarily on material from the Helidon Sandstone, additional samples from other formations have been examined, to provide additional data on correlation with the sequence in the Surat Basin and on the age relationships of the sediments. These additional samples came from the Marburg Formation, which conformably overlies the Helidon Sandstone, from underlying sediments correlated with the Triassic Raceview Formation and from the Ripley Road Sandstone. The latter formation is at the top of the Triassic sequence in the Bundamba Group of the Ipswich area; samples from it have been examined to study the relationship of this Late Triassic sequence to the Jurassic Helidon-Marburg succession.

The formations investigated were all deposited largely, if not entirely, in a continental environment. Plant macrofossils have been collected from some of them, but generally the miospores appear to be more useful, in detailed correlation of these sediments. This is because of their wide distribution, particularly in cores of stratigraphic drillholes which, in many cases, yield few, if any macrofossils. In addition to these correlation studies, a further objective has been to examine microfloral evidence on the age of the sediments. This aspect is of particular interest in this area of south-eastern Queensland, in view of recent evidence (de Jersey, 1970b, p. 22) suggestive of a gradual transition from the Late Triassic microflora of the Raceview Formation to assemblages of Liassic character, in the overlying sediments.

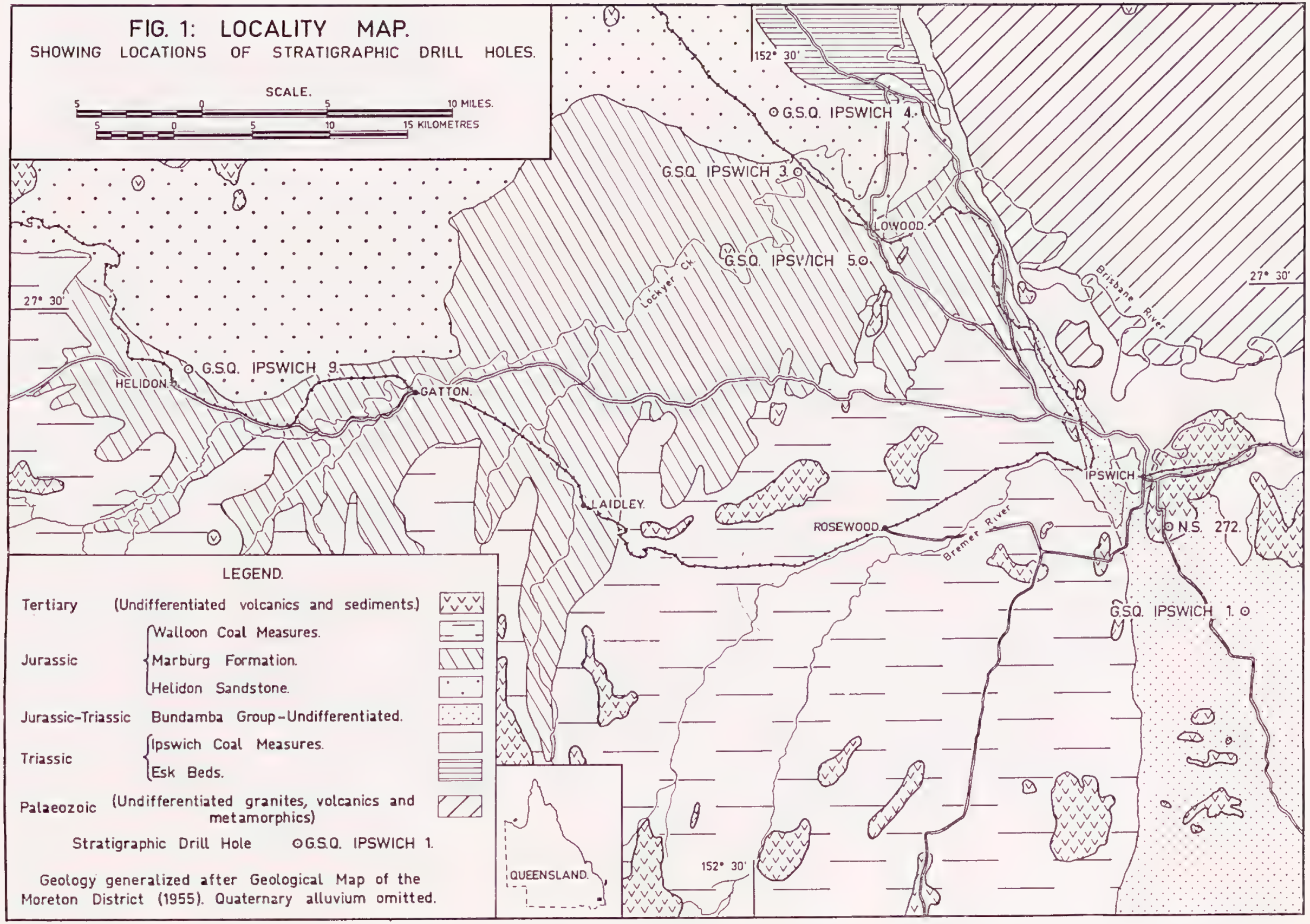
FIG. 1: LOCALITY MAP.

SHOWING LOCATIONS OF STRATIGRAPHIC DRILL HOLES.

SCALE.

5 0 5 10 MILES.

5 0 5 10 15 KILOMETRES



LEGEND.

Tertiary	(Undifferentiated volcanics and sediments.)	
Jurassic	Walloon Coal Measures.	
	Marburg Formation.	
	Helidon Sandstone.	
Jurassic-Triassic	Bundamba Group-Undifferentiated.	
Triassic	Ipswich Coal Measures.	
	Esk Beds.	
Palaeozoic	(Undifferentiated granites, volcanics and metamorphics)	

Stratigraphic Drill Hole ⊙G.S.Q. IPSWICH 1.

Geology generalized after Geological Map of the Moreton District (1955). Quaternary alluvium omitted.

STRATIGRAPHIC DISCUSSION

The material studied came from holes drilled in the course of the stratigraphic drilling programme of the Geological Survey of Queensland. They were continuously cored to depths of the order of 1200 feet; their locations are shown on the locality map (Figure 1). Investigation of the microfloral sequence of the Helidon Sandstone, and of the underlying and overlying sediments, was based primarily on samples from G.S.Q. Ipswich 3, 4 and 5, drilled during 1969 in the Lowood area. The sediments known in outcrop to the north of Lowood were previously assigned to the Wivenhoe Sandstone. However this unit is known to be co-extensive, in surface outcrop, with the Helidon Sandstone, the type area of which is further to the west, north of Helidon. The latter name is preferred for the formation, as it has chronological priority (A. R. G. Gray, pers. comm.).

In the sediments cored by these stratigraphic holes, the section which is deepest, stratigraphically, was penetrated by G.S.Q. Ipswich 4. This hole reached total depth at 1201 feet, in sediments correlated, on lithological evidence, with the Esk Beds. Two samples, from depths of 1170 feet 2 inches and 1174 feet 11 inches, in these basal sediments, were processed, but did not yield any identifiable microfossils. This section is overlain, at a depth of 1169 feet, by strata correlated with the Raceview Formation, which in turn are succeeded by the Helidon Sandstone at a depth of 991 feet. The latter formation extends to the surface in this hole.

A section, which includes sediments higher in the sequence, was cored in G.S.Q. Ipswich 3. This hole reached a total depth of 1200 feet in the Helidon Sandstone, which is succeeded by the Marburg Formation at a depth of 200 feet. The latter unit is distinguished in the subsurface from the Helidon Sandstone by the more lithic nature and somewhat greenish colour of the sandstones it contains and by having a greater proportion of interbedded shale and mudstone (A. R. G. Gray, pers. comm.). In G.S.Q. Ipswich 5 total depth was reached at 1200 feet, in the Helidon Sandstone. A gradational change to the overlying Marburg Formation takes place in the interval between 1000 and 1200 feet; the latter formation extends to the surface.

The sections encountered in these holes have been correlated with each other, on the basis of lithological evidence and the slight regional dip to the south in this area. This correlation is shown diagrammatically in Figure 2. It will be evident that, taken in conjunction, they provide a continuously cored record through a stratigraphic thickness of 2430 feet of sediments, comprising (above the Esk Beds at the base) 178 feet of Raceview Formation, 1181 feet of Helidon Sandstone, and 1040 feet of lower and middle Marburg Formation.

To the west, G.S.Q. Ipswich 9 was drilled to provide material from the type area of the Helidon Sandstone. It reached total depth at 1015 feet in granite, the base of the Raceview Formation being at 995 feet. This is succeeded by Helidon Sandstone at 742 feet: the top of this formation is at a depth of 95 feet, above which it is overlain by the Marburg Formation.

Finally, samples were obtained from cores of two holes drilled in the Ripley Road Sandstone, to the south-east of Ipswich. These are N.S. 272 (Ipswich) and G.S.Q. Ipswich 1. The lithological sequence penetrated in the former has been recently described (de Jersey, 1970b, p. 2). As part of the present investigation, two samples from the Ripley Road Sandstone, which extends from 446 to 1183 feet in this hole, have been examined. This interval has been selected as the type section of this formation (Staines, 1964, p. 34). The other hole, G.S.Q. Ipswich 1, was drilled in 1968 to a total depth of 1242 feet. The lower part of this hole penetrated a section disturbed by faulting, but regarded as equivalent to the Raceview Formation. This is overlain by the Ripley Road Sandstone at 711 feet; the latter formation extends to the surface in this hole (A. R. G. Gray, pers. comm.).

PROCESSING OF SAMPLES

Samples from these stratigraphic holes comprise pieces of core about ½ to 1 inch in vertical thickness; their depths are recorded in the Appendix of this paper. They all consist of relatively fine grained sediments (shale, mudstone or siltstone). The investigation has been based on samples of these fine sediments as they give much better yields of plant microfossils than the intervening sandstones. In this respect continuous coring of the stratigraphic holes has been of great advantage, particularly in the case of the Helidon Sandstone, in which the beds of shale and siltstone are relatively thin, in relation to the interbedded quartzose sandstone, which constitutes the dominant portion of the sequence in this formation.

After crushing, silicates were removed by treatment with hydrofluoric acid, followed by heating in dilute hydrochloric acid to remove insoluble fluorides. The residue was then subjected to mild oxidation, with dilute nitric acid. At each stage of the process the carbonaceous material was washed to neutrality by centrifuging. After oxidation the residue was subjected to specific gravity separation in zinc chloride or zinc bromide solution; in this way large amounts of opaque carbonaceous matter were removed, thus enhancing the proportion of spores and pollen grains in the final residues, from which permanent microslides were prepared. A balsam-based mounting medium was used in preparation of the permanent microslides.

In accordance with the writer's previous practice figured specimens are located by the stage co-ordinates of a Carl Zeiss GFL Microscope. In addition to the specimen co-ordinates, co-ordinates of a reference point, arbitrarily selected as the lower right hand corner of the cover glass, are recorded in the text for each figured specimen. With this information the specimens can be readily located by means of a microscope equipped with a mechanical stage. Microslides prepared during the investigation are stored in the collection of the Palynology Section, Geological Survey of

Queensland. Maceration residues from all samples are also stored in the collection of the Palynology Section and the samples themselves are stored in the Core Library of the Geological Survey.

SYSTEMATIC DESCRIPTIONS

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reinsch *emend.* Dettmann, 1963

Subturma AZONOTRILETES Luber *emend.* Dettmann, 1963

Infraturma LAEVIGATI Bennie & Kidston *emend.* Potonié, 1956

Genus CALAMOSPORA Schopf, Wilson & Bentall, 1944

Type species: Calamospora hartungiana Schopf, in Schopf, Wilson & Bentall, 1944.

Calamospora tener (Leschik) de Jersey, 1962

Distribution: Keuper of Switzerland (Leschik, 1955); Karnian of Austria (Klaus, 1960); Middle and Upper Triassic and Lower Jurassic of Germany (Mädler, 1964a; Schulz, 1966); Jurassic of Great Britain (Couper, 1958). Queensland records: Triassic of Ipswich Coal Measures (de Jersey, 1962, 1970b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Jurassic of Marburg Formation (this paper).

Genus CYATHIDITES Couper, 1953

Type species: Cyathidites australis Couper, 1953.

Cyathidites australis Couper, 1953

Plate 1, Figure 1

Figured specimen: Slide S2464, stage co-ordinates 14.0, 89.5; diameter 56 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 83.4.

Locality: G.S.Q. Ipswich 5, 234 feet, 2 inches (Marburg Formation).

Distribution: Widely distributed in Mesozoic sediments. Queensland records: Jurassic of Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Marburg Formation (this paper).

Cyathidites minor Couper, 1953

Plate 1, Figure 3

Figured specimen: Slide S2439, stage co-ordinates 17.0, 87.0; diameter 26 microns, Co-ordinates of lower right hand corner of cover glass 25.2, 82.5.

Locality: G.S.Q. Ipswich 5, 578 feet, 8 inches (Marburg Formation).

Remarks: Only specimens with concavely subtriangular ambs, as specified in the original diagnosis (Couper, 1953, p. 28) have been assigned to this species. Other spores, which are convexly subtriangular, have been recorded as *Leiotriletes directus* Balme and and Hennelly.

Distribution: Widely distributed in Mesozoic sediments. Queensland records: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969); Jurassic Razorback Beds (Playford and Cornelius, 1967); Jurassic of Marburg Formation (this paper).

Genus DICTYOPHYLLIDITES Couper *emend.* Dettmann, 1963

Type species: Dictyophyllidites harrisii Couper, 1958.

Dictyophyllidites harrisii Couper, 1958

Remarks: As stated by Playford (1965, p. 179) this species is generally larger than *Dictyophyllidites mortoni* (de Jersey) Playford and Dettmann, 1965 and its exinal thickenings are less prominent.

Distribution: Jurassic of Great Britain (Couper, 1958); Lower Jurassic of Hungary (Góczán, 1956); Triassic of Austria (Bharadwaj and Singh 1964); Triassic of Tasmania (Playford, 1965); Triassic of Moolayember Formation, Clematis Sandstone (de Jersey and Hamilton, 1967; de Jersey, 1968); Jurassic of Helidon Sandstone (this paper).

Dictyophyllidites mortoni (de Jersey) Playford & Dettmann, 1965

Distribution: Jurassic of Walloon Coal Measures, Marburg Formation, Helidon Sandstone (de Jersey, 1959, 1963, this paper); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Ipswich Coal Measures (de Jersey, 1962); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Tasmania (Playford, 1965); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b), Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper).

Genus GLEICHENIIDITES Ross ex Delcourt & Sprumont *emend.* Dettmann, 1963

Type species: Gleicheniidites senonicus Ross, 1949.

Gleicheniidites senonicus Ross, 1949

Remarks: This species is recorded in one assemblage from the Marburg Formation.

Distribution: Widely recorded from Jurassic, Cretaceous and Tertiary sediments. Queensland records: Evergreen Formation (Reiser and Williams, 1969); Marburg Formation (this paper).

Genus LEIOTRILETES (Naumova) Potonié & Kremp, 1954

Type species: Leiotriletes sphaerotriangulus (Loose) Potonié & Kremp, 1954.

Leiotriletes directus Balme & Hennelly, 1956

Remarks: Spores of this simple, generalized type are virtually ubiquitous in lower Mesozoic assemblages from Queensland.

Genus STEREISPORITES Pflug *emend.* de Jersey, 1964

Type species: Stereisporites stereoides (Potonié & Venitz) Pflug, 1953.

Stereisporites antiquasporites (Wilson & Webster) Dettmann, 1963

Distribution: Widely distributed in Mesozoic and Tertiary sediments. Queensland records: Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964; Hill, Playford and Woods, 1965; de Jersey, 1970b); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone (this paper).

Stereisporites perforatus Leschik, 1955

Distribution: Widely distributed in Mesozoic sediments. Queensland records: Triassic of Blackstone Formation, Raceview Formation, Ripley Road Sandstone (Hill, Playford and Woods, 1965; de Jersey, 1970b, this paper); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Precipice Sandstone, Evergeen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Infraturma APICULATI Bennie & Kidston *emend.* Potonié, 1965

Subinfraturma VERRUCATI Dybová & Jachowicz, 1957
Genus CONVERRUCOSISPORITES Potonié & Kremp, 1954

Type species: Converrucosisporites triquetrus (Ibrahim) Potonié & Kremp, 1959.

Converrucosisporites cameroni (de Jersey) Playford & Dettmann, 1965

Distribution: Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964, 1970b, this paper); Triassic and Jurassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a).

Genus CRATERISPORITES de Jersey, 1970

Type species: Craterisporites rotundus de Jersey, 1970.

Craterisporites rotundus de Jersey, 1970

Remarks: A few specimens of this species have been observed in assemblages from the Raceview Formation.

Distribution: Blackstone Formation, Aberdare Conglomerate, Raceview Formation (de Jersey, 1970b, this paper).

Subinfraturma NODATI Dybová & Jachowicz, 1967

Genus ANAPICULATISPORITES Potonié & Kremp, 1954

Type species: Anapiculatisporites isselburgensis Potonié & Kremp, 1954.

Anapiculatisporites dawsonensis Reiser & Williams, 1969

Plate 1, Figure 5

Figured specimen: Slide S2388; stage co-ordinates 21.7, 93.7; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.0.

Locality: G.S.Q. Ipswich 3, 825 feet, 2 inches (Helidon Sandstone).

Distribution: Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Raceview Formation, Ripley Road Sandstone, Helidon Sandstone, Marburg Formation (this paper).

Anapiculatisporites pristidentatus Reiser & Williams, 1969

Plate 1, Figure 2

Figured specimen: Slide S2400, stage co-ordinates 15.5, 40.3; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 26.1, 84.6.

Locality: G.S.Q. Ipswich 3, 153 feet, 3 inches (Marburg Formation).

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone; Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1970b, this paper).

Genus APICULATISPORIS Potonié & Kremp, 1956

Type species: Apiculatisporis aculeatus (Ibrahim) Potonié, 1956.

Apiculatisporis globosus (Leschik) Playford & Dettmann, 1965

Plate 1, Figure 4

Figured specimen: Slide S2503, stage co-ordinates 13.8, 86.8; diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 86.9.

Locality: G.S.Q. Ipswich 9, 824 feet, 6 inches (Raceview Formation).

Distribution: Middle Keuper of Switzerland (Leschik, 1955); Liassic of Sweden (Nilsson, 1958); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford 1965); Triassic of Blackstone Formation, Raceview Formation, Ripley Road Sandstone (Hill, Playford and Woods, 1965; de Jersey, 1970b, this paper); Jurassic of Helidon Sandstone (this paper).

Apiculatisporis taroomensis Reiser & Williams, 1969

Plate 1, Figure 7

Figured specimen: Slide S2402, stage co-ordinates 18.8, 95.1; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 26.6, 83.1.

Locality: G.S.Q. Ipswich 3, 130 feet, 9 inches (Marburg Formation).

Remarks: This species is relatively rare in the material studied. It has been recorded in two assemblages from the Marburg Formation.

Distribution: Precipice Sandstone, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Marburg Formation (this paper).

Genus FORAMINISPORIS Krutzsch, 1959

Type species: Foraminisporis foraminis Krutzsch, 1959.

Foraminisporis tribulosus Playford & Dettmann, 1965

Plate 1, Figure 6

Figured specimen: Slide S2351, stage co-ordinates 20.1, 95.6; diameter 37 microns. Co-ordinates of lower right hand corner of cover glass 27.3, 84.8.

Locality: G.S.Q. Ipswich 4, 639 feet, 11 inches (Helidon Sandstone).

Remarks: The specimen figured is the only specimen of this species observed in the assemblages studied.

Distribution: Liassic of Leigh Creek Coal Measures, South Australia (Playford & Dettmann, 1965); lower Precipice Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); lower Helidon Sandstone (this paper).

Genus OSMUNDACIDITES Couper, 1953

Type species: Osmundacidites wellmanii Couper, 1953.

Remarks: Apart from spores assigned to *Osmundacidites wellmanii,* recorded below and in the assemblage lists, no specific identification of specimens assigned to *Osmundacidites* has been made. It appears likely that such specific differentiation would have little, if any, stratigraphic application, in the section studied.

Osmundacidites wellmanii Couper, 1953

Distribution: Very widespread in Mesozoic sediments (for Queensland records see de Jersey, 1970b, p. 6). Additional record: Helidon Sandstone (this paper).

Genus PUSTULATISPORITES Potonié & Kremp, 1954

Type species: Pustulatisporites pustulatus Potonié & Kremp, 1954.

Pustulatisporites blackstonensis de Jersey, 1970

Remarks: This species is a rare component of some assemblages from the Raceview Formation.

Distribution: Blackstone Formation, Aberdare Conglomerate (de Jersey, 1970b); Raceview Formation (this paper).

Subinfraturma BACULATI Dybová & Jachowicz, 1957

Genus BACULATISPORITES Thomson & Pflug, 1953

Type species: Baculatisporites primarius (Wolff) Thomson & Pflug, 1953.

Baculatisporites comaumensis (Cookson) Potonié, 1956

Distribution: Widespread in Australian Mesozoic sediments; has been reported in Europe from the Upper Muschelkalk onwards (Klaus, 1960; Schulz, 1966). Queensland records: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Cretaceous of Wallumbilla Formation (de Jersey and Paten, 1964); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation (de Jersey, 1970b); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Genus CADARGASPORITES de Jersey & Paten *emend.* Reiser & Williams, 1969

Type species: Cadargasporites baculatus de Jersey & Paten *emend.* Reiser & Williams, 1969.

Cadargasporites baculatus de Jersey & Paten *emend.* Reiser & Williams, 1969

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, basal Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Triassic of Blackstone Formation, Raceview Formation, Ripley Road Sandstone (de Jersey 1970b, this paper); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Cadargasporites granulatus de Jersey & Paten *emend.* Reiser & Williams, 1969

Remarks: This species is a rare component of the Helidon and Marburg assemblages.

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (de Jersey and Paten, 1964; Reiser and Williams, 1969); Triassic of Raceview Formation (de Jersey, 1970b); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Cadargasporites reticulatus de Jersey & Paten, 1964

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Triassic of Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, this paper); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Cadargasporites verrucosus Reiser & Williams, 1969

Remarks: This species is relatively rare in the material studied. Only four specimens were recorded, all in assemblages from the Marburg Formation.

Distribution: Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969); Marburg Formation (this paper).

Genus CERATOSPORITES Cookson & Dettmann, 1958

Type species: Ceratosporites equalis Cookson & Dettmann, 1958.

Remarks: Potonié's distinction (1960, p. 43) between *Neoraistrickia* and *Ceratosporites,* based on the presence of a smooth proximal exine in the latter genus, is supported here. Schulz (1967, p. 563) has widened the specific circumscription of the type species of *Neoraistrickia, N. truncata* (Cookson) Potonié, 1956 by including European spores with smooth proximal

exines. This alteration of the specific concept of *N. truncata* cannot be accepted until it is supported by evidence based on material from the type locality, demonstrating continuous gradation from specimens with smooth proximal exines to others sculptured proximally. The available evidence does not record any such gradation; specimens of *N. truncata* from the type locality described by Cookson and Dettmann (1958, p. 101) all have distinct proximal sculpture.

Ceratosporites helidonensis sp. nov.

Plate 1, Figures 8, 9, 10, 11; Plate 2, Figure 1

Diagnosis: Trilete miospores. Amb convexly subtriangular to subcircular. Diameter, excluding projections (based on 70 measured specimens) 27 to 46 microns. Laesurae straight, without any marked development of lips; length varies from about half to almost equal spore radius. Equatorial exine with moderately dense sculpture of spinae, about 2 to 5 microns in length, 1 to 2 microns in basal diameter, set about 2 microns apart. Apices of spinae mostly pointed; a few bifurcate. Sculptural elements slightly to distinctly reduced in size towards distal pole; distal elements mainly coni and verrucae, about 1.5 microns in height and basal diameter. Proximal exine smooth. Distal exine (apart from larger sculptural elements) smooth or faintly scabrate. Exine slightly to distinctly arched distally, thickness in equatorial region about 1 to 2 microns.

Holotype (*Plate* 1, *Figure* 9): Slide S2518, stage co-ordinates 22.0, 92.0; diameter (excluding spines) 43 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 84.1.

Locality: G.S.Q. Ipswich 9, 612 feet, 7 inches (lower Helidon Sandstone).

Figured specimen: (*Plate* 1, *Figure* 8): Slide S2516, stage co-ordinates 21.0, 95.4; diameter (excluding spines) 40 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.2.

Figured specimen: (*Plate* 1, *Figures* 10, 11—*proximal, distal foci*): Slide S2382, stage co-ordinates 9.7, 92.3; diameter (excluding spines) 40 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.7.

Locality: G.S.Q. Ipswich 3, 825 feet, 2 inches (middle Helidon Sandstone).

Figured specimen (*Plate* 2, *Figure* 1): Slide S2347, stage co-ordinates 16.2, 91.8; diameter (excluding spines) 40 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.6.

Locality: G.S.Q. Ipswich 4, 435 feet, 5 inches (middle Helidon Sandstone).

Variation: Appreciable variation exists in the extent of reduction of the distal sculptural elements. This reduction may be relatively moderate, as in the specimen figured in Plate 1, Figures 10 and 11, or quite marked, as in those figured in Plate 1, Figure 8 and Plate 2, Figure 1. In the latter specimen, with extreme reduction of the distal sculpture, a smooth, unornamented area is developed around the distal pole. The holotype (Plate 1, Figure 9) illustrates an intermediate stage in this distal reduction of the sculptural elements. The specimens figured also illustrate variation in the shape of the amb, from subtriangular (Plate 2, Figure 1) to subcircular (Plate 1, Figure 9), and in the length of the laesurae, from about half the amb radius (Plate 2, Figure 1) to more than three-quarters of the radius (Plate 1, Figures 10 and 11). Some specimens show secondary folding at the equator; less frequently, arcuate folds are present at the ends of the laesurae.

Remarks: The specific name indicates provenance of the type material from the Helidon Sandstone; the species is a characteristic component of assemblages from the lower and middle parts of this formation. It has been assigned to *Ceratosporites* because the equatorial projections are moderately elongate and spinose, rather than conate, as in *Anapiculatisporites.*

Ceratosporites helidonensis differs from the Cretaceous type species, *C. equalis* Cookson & Dettmann (Cookson and Dettmann, 1958, pp. 101, 102) in having spinose, rather than baculate projections, and in the distal reduction of its sculptural elements. The latter species also has prominent tectate laesurae, in contrast to the less conspicuous trilete mark of the Queensland species.

The Liassic species *C. spinosus* Schulz, from East Germany (Schulz, 1967, pp. 563, 564) has sculptural elements somewhat similar to those of *C. helidonensis,* but these are more widely spaced at the equator. In addition this European species differs in having longer laesurae and small tubercles on the proximal surface and appears to lack any significant reduction of the sculptural elements towards the distal pole.

No close comparison can be made with other species, previously described from Australian Mesozoic sediments. The Cretaceous species *Acanthotriletes levidensis* Balme (Balme. 1957, p. 18) and the Jurassic species *A. pallidus* de Jersey (de Jersey, 1959, p. 357) have distal spinose sculpture, but in neither case is there any significant reduction of the sculptural elements towards the distal pole. The same distinction applies, with reference to *Anapiculatisporites dawsonensis* Reiser & Williams and *A. pristidentatus* Reiser & Williams (Reiser and Williams, 1969, pp. 3, 4). The two latter species are further distinguished by their dominantly conate (not spinose) sculpture.

Another species, which shows some similarity to *Ceratosporites helidonensis* is *Neoraistrickisporites propunctatus*, described by Rioult (1965, p. 287) from the Infraliassic of northern France. This species is similar in size to the Queensland spores, but the equatorial projections are somewhat more elongate and baculate rather than spinose. In addition there is no mention in the description of reduction of the sculptural elements towards the distal polar region and the proximal face is finely punctate, while the laesurae normally reach the equator—features not observed in *C. helidonensis.*

Distribution: Lower and middle Helidon Sandstone, uppermost Ripley Road Sandstone (this paper).

Genus CONBACULATISPORITES Klaus, 1960

Type species: Conbaculatisporites mesozoicus Klaus, 1960.

Remarks: This genus has much in common with *Neoraistrickia* Potonié, 1956, but generic distinction is possible on the basis of its having smaller sculptural elements, which are more densely packed, particularly in the radial regions (as illustrated by the type species *C. mesozoicus*).

Conbaculatisporites sp. A

Plate 2, Figure 2

Figured specimen: Slide S2382, stage co-ordinates 23.0, 93.7; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.4.

Locality: G.S.Q. Ipswich 3, 825 feet, 2 inches (Helidon Sandstone).

Remarks: The specimen figured is characterized by the development of bacula in the radial regions, which tend to be reduced to coni and grana inter-radially, and by the presence of proximal exinal thickenings. The latter feature appears to distinguish it from the type species, *Conbaculatisporites mesozoicus* Klaus, 1960. As only four spores of this type have been observed, insufficient specimens are available to justify formal taxonomic treatment.

Distribution: Upper Ripley Road Sandstone, lower and middle Helidon Sandstone (this paper).

Genus NEORAISTRICKIA Potonié, 1956

Type species: Neoraistrickia truncata (Cookson) Potonié, 1956.

Neoraistrickia elongata Reiser & Williams, 1969

Plate 2, Figures 4 and 5

Figured specimen (Plate 2, Figures 4, 5—equatorial, proximal foci): Slide S2444, stage co-ordinates 9.1, 91.9; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 25.5, 86.2.

Locality: G.S.Q. Ipswich 5, 530 feet, 1 inch (Marburg Formation).

Distribution: Precipice Sandstone, Evergreen Formation, Lower Hutton Sandstone (Reiser and Williams, 1969); Helidon Sandstone, Marburg Formation (this paper).

Neoraistrickia taylorii Playford & Dettmann, 1965

Plate 2, Figure 3

Figured specimen: Slide S2396, stage co-ordinates 18.1, 96.0; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 25.1, 85.5.

Locality: G.S.Q. Ipswich 3, 531 feet, 1 inch (Helidon Sandstone).

Distribution: Triassic and Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Late Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Blackstone Formation, Raceview Formation (Hill, Playford and Woods, 1965; de Jersey, 1970b); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Infraturma MURORNATI Potonié & Kremp, 1954

Genus DUPLEXISPORITES Deák *emend.* Playford & Dettmann, 1965

Type species: Duplexisporites generalis Deák, 1962.

Duplexisporites problematicus (Couper) Playford & Dettmann, 1965

Plate 2, Figure 6

Figured specimen: Slide S2334, stage co-ordinates 12.3, 90.5; diameter 48 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 83.0.

Locality: G.S.Q. Ipswich 4, 1125 feet, 1 inch (Raceview Formation).

Remarks: Reference should be made to a recent paper (de Jersey, 1970b, p. 8) for a discussion of the morphology and synonymy of this species.

Distribution: Middle Jurassic to Lower Cretaceous of Great Britain (Couper, 1958); Middle Keuper to Lower Cretaceous of East Germany (Schulz, Döring, *et al.,* 1966; Schulz, 1967); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Upper Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Mount Crosby Formation, Tingalpa and Moorooka Formations (de Jersey and Hamilton, 1965a, 1965b); Triassic of Wandoan Formation (de Jersey and Hamilton, 1969); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964; Hill, Playford and Woods, 1965; de Jersey, 1970b); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (de Jersey and Paten, 1964, Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Genus FOVEOSPORITES Balme, 1957

Type species: Foveosporites canalis Balme, 1957.

Foveosporites moretonensis de Jersey, 1964

Distribution: Triassic of Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Gems ISCHYOSPORITES Balme, 1957

Type species: Ischyosporites crateris Balme, 1957.

Ischyosporites marburgensis de Jersey, 1963

Plate 3, Figure 12

Figured specimen: Slide S2461, stage co-ordinates 24.1, 94.6; diameter 66 microns. Co-ordinates of lower right hand corner of cover glass 24.0, 94.6.

Locality: G.S.Q. Ipswich 5, 234 feet, 2 inches (Marburg Formation).

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of upper Helidon Sandstone, Marburg Formation (de Jersey, 1963, this paper).

Genus LYCOPODIACIDITES Couper *emend.* Potonié, 1956

Type species: Lycopodiacidites bullerensis Couper, 1953.

Lycopodiacidites sp. cf. *L. kuepperi* Klaus, 1960

Plate 2, Figure 9

Figured specimen: Slide S2412, stage co-ordinates 19.3, 99.8; diameter 76 microns. Co-ordinates of lower right hand corner of cover glass 25.2, 83.4.

Locality: N.S. 272, 603 feet, 4 inches (Ripley Road Sandstone).

Remarks: The specimen figured is closely comparable in most features with *Lycopodiacidites kuepperi* Klaus (Klaus, 1960, p. 135) but because the preservation of the distal exine does not permit detailed comparison of the sculpture patterns, it is not formally identified with the Austrian species. It is the only specimen of this type observed in the present material.

Distribution of L. kuepperi: Karnian of Austria (Klaus, 1960), Lower and Middle Keuper of East Germany (Schulz, 1966).

Genus LYCOPODIUMSPORITES Thiergart ex Delcourt & Sprumont, 1955

Type species: Lycopodiumsporites agathoecus (Potonié) Thiergart, 1938.

Lycopodiumsporites austroclavatidites (Cookson) Potonié, 1956

Plate 3, Figures 1 and 2

Figured specimen (*Plate* 3, *Figures* 1, 2—*proximal, distal foci*): Slide S2390, stage co-ordinates 7.9, 102.2; diameter 41 microns. Co-ordinates of lower right hand corner of cover glass 25.6, 87.5.

Locality: G.S.Q. Ipswich 3, 575 feet, 10 inches (Helidon Sandstone).

Remarks: The assignment by Schulz (1967, p. 575) to this species of spores with reticulate proximal exines requires confirmation, as Dettmann (1963, p. 44) who studied material close, both stratigraphically and geographically to Cookson's type material, described the exine as "smooth proximally".

Distribution: Widely distributed in Jurassic and Cretaceous sediments; reported from Middle Rhaetic and Liassic of East Germany (Schulz, 1967). Queensland records: Jurassic of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone, Marburg Formation, Triassic of upper Ripley Road Sandstone (this paper).

Lycopodiumsporites rosewoodensis (de Jersey) de Jersey, 1963

Plate 3, Figures 4 and 5

Figured specimen (*Plate* 3, *Figures* 4, 5—*distal, proximal foci*): Slide S2392, stage co-ordinates 17.8, 89.6; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 25.1, 82.2.

Locality: G.S.Q. Ipswich 3, 575 feet, 10 inches (Helidon Sandstone).

Distribution: Walloon Coal Measures (de Jersey, 1959); Jurassic of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic Razorback Beds (Playford and Cornelius, 1967); Triassic of Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, this paper); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1963, this paper).

Lycopodiumsporites semimuris (Danzé-Corsin & Laveine) Reiser & Williams, 1969

Plate 3, Figure 3

Figured specimen: Slide S2403, stage co-ordinates 21.1, 90.7; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 24.3, 86.0.

Locality: G.S.Q. Ipswich 3, 130 feet, 9 inches (Marburg Formation).

Distribution: Rhaetian, Lower and Middle Jurassic of France (Briche *et al.*, 1963; Levet-Carette, 1964a,b); Lower Jurassic of Canada (McGregor, 1965); Precipice Sandstone, Evergreen Formation of Surat Basin (Reiser and Williams, 1969); Upper Ripley Road Sandstone, Helidon Sandstone, Marburg Formation (this paper).

Genus STAPLINISPORITES Pocock, 1962

Type species: Staplinisporites caminus (Balme) Pocock, 1962.

Staplinisporites caminus (Balme) Pocock, 1962

Distribution: Upper Jurassic of Western Australia (Balme, 1957); Lower Cretaceous of south-eastern Australia (Dettmann, 1963); Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Marburg Formation (this paper).

Turma ZONALES Bennie & Kidston *emend.* Potonié, 1956

Subturma AURITOTRILETES Potonié & Kremp, 1954
Infraturma AURICULATI Schopf *emend.* Dettmann, 1963

Genus TRILOBOSPORITES Pant ex Potonié, 1950

Type species: Trilobosporites hannonicus (Delcourt & Sprumont) Potonié, 1956.

Trilobosporites antiquus Reiser & Williams, 1969

Plate 3, Figure 11

Figured specimen: Slide S2468, stage co-ordinates

18.8, 86.0; diameter 64 microns. Co-ordinates of lower right hand corner of cover glass 25.8, 85.9.

Locality: G.S.Q. Ipswich 5, 204 feet, 9 inches (Marburg Formation).

Distribution: Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Marburg Formation (this paper).

Subturma ZONOTRILETES Waltz, 1935

Infraturma TRICRASSATI Dettmann, 1963

Genus CAMAROZONOSPORITES Pant ex Potonié *emend.* Klaus, 1960

Type species: Camarozonosporites cretaceus (Weyland & Krieger) Potonié, 1956.

Camarozonosporites rudis (Leschik) Klaus, 1960

Remarks: This species is a rare component of the Helidon and Raceview assemblages.

Distribution: Keuper of Switzerland (Leschik, 1955); Karnian, Norian, Rhaetian and Liassic of Austria (Klaus, 1960 and pers. comm.); Middle and Upper Keuper and Liassic of Germany (Mädler, 1964a, 1964b; Schulz, 1966, 1967); Keuper and lower Rhaetian of Poland (Orlowska-Zwolinska, 1964); Upper Triassic of Canada (McGregor, 1965); Jurassic of Razorback Beds, Queensland (Playford and Cornelius, 1967); Precipice Sandstone, Evergreen Formation of Surat Basin (Reiser and Williams, 1969); Triassic of Aberdare Conglomerate, Raceview Formation (de Jersey, 1970b, this paper); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Genus ZEBRASPORITES Klaus, 1960

Type species: Zebrasporites kahleri Klaus, 1960.

Remarks: The generic diagnosis of Klaus (1960, p. 137) is preferred to that of Schulz (1967, p. 589). Schulz (*loc. cit.*) widened the interpretation of *Zebrasporites* to include his species Z. *laevigatus,* which has a smooth distal exine. It is considered that this species could be more appropriately assigned to *Rotaspora* Schemel *emend.* Smith and Butterworth, 1967, which includes smooth species of similar construction, and that *Zebrasporites* should be restricted to species with distal rugulae, as in the type species.

Zebrasporites interscriptus (Thiergart) Klaus, 1960

Plate 3, Figure 6

Figured specimen: S1780, stage co-ordinates 24.7, 95.6; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 27.7, 85.2.

Locality: G.S.Q. Ipswich 1, 483 feet, 7 inches (Ripley Road Sandstone).

Remarks: Three specimens of this species have been recorded in an assemblage from the Ripley Road Sandstone. They conform, in all significant diagnostic features, to the description and figures of Schulz (1967, p. 589; pl. 15, figs. 8, 9). The discovery of this European species in the Ripley Road section provides additional evidence bearing on the correlation of the Queensland and European microfloral sequences; this correlation is discussed in a later section of this paper.

Distribution: Keuper of Central Germany (Thiergart, 1949); Middle Keuper, Rhaetian and Liassic of East Germany (Schulz, 1962, 1966, 1967); Rhaetian and Liassic of Poland (Orlowska-Zwolinska, 1964, 1966); late Karnian, Norian and Rhaetian of West Germany and England (Geiger and Hopping, 1968); Ripley Road Sandstone (this paper).

Infraturma CINGULATI Potonié & Klaus emend. Dettmann, 1963

Genus ANNULISPORA de Jersey, 1959

Type species: Annulispora folliculosa (Rogalska) de Jersey, 1959.

Annulispora folliculosa (Rogalska) de Jersey, 1959

Plate 2, Figure 7

Figured specimen: Slide S2438, stage co-ordinates 19.6, 88.2; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 26.3, 85.5.

Locality: G.S.Q. Ipswich 5, 578 feet, 8 inches (Marburg Formation).

Distribution: Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b); Upper Triassic of Tasmania (Playford, 1965); Liassic of Poland (Rogalska, 1954); Jurassic of Helidon Sandstone, Marburg Formation, Walloon Coal Measures (de Jersey, 1959, 1963, this paper); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967).

Annulispora microannulata de Jersey, 1962

Plate 3, Figure 7

Figured specimen: Slide S2395, stage co-ordinates 12.9, 91.6; diameter 28 microns. Co-ordinates of lower right hand corner of cover glass 24.5, 85.8.

Locality: G.S.Q. Ipswich 3, 531 feet, 1 inch (Helidon Sandstone).

Distribution: Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964, 1970b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1963, this paper).

Genus ANTULSPORITES Archangelsky & Gamerro, 1966

Type species: Antulsporites baculatus (Archangelsky & Gamerro) Archangelsky & Gamerro, 1966.

Antulsporites varigranulatus (Levet-Carette) Reiser & Williams, 1969

Plate 2, Figure 8

Figured specimen: Slide S2431, stage co-ordinates 19.7, 98.6; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 25.7, 82.9.

Locality: G.S.Q. Ipswich 5, 690 feet, 5 inches (Marburg Formation).

Remarks: The first appearance of this species, within the Helidon Sandstone, appears to be of stratigraphic significance in the section studied.

Distribution: Infraliassic of France (Levet-Carette, 1964a); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation, Walloon Coal Measures (de Jersey, 1959, this paper).

Genus CINGUTRILETES Pierce *emend.* Dettmann, 1963

Type species: Cingutriletes congruens Pierce, 1961.

Remarks: Potonié (1966, pp. 79, 81) has widened the generic diagnosis of *Murospora* Somers, 1952 to include spores with subcircular ambs, as well as triangular or subtriangular species, and has placed *Cingutriletes* in synonymy with *Murospora,* so emended. This interpretation is not supported here; the writer prefers to follow Playford's (1962, p. 608) and Dettmann's (1963, p. 70) usage, in restricting *Murospora* to spores with triangular or subtriangular ambs.

On the basis of Dettmann's diagnosis (1963, p. 69) *Cingutriletes* is apparently close to *Densosporites* Berry *emend.* Butterworth *et al.,* 1964. However the latter authors (Butterworth *et al.,* 1964, p. 101) regard the presence of a two-layered exine as one of the essential features of *Densosporites*; the presence of an intexine has not been demonstrated in *Cingutriletes.* Provisionally, *Cingutriletes* should be retained as a distinct genus until more is known of the morphology of its briefly described type species.

Cingutriletes sp. cf. *C. clavus* (Balme) Dettmann, 1963

Plate 3, Figure 8

Figured specimen: Slide S2386, stage co-ordinates 12.3, 93.7; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 25.3, 85.6.

Locality: G.S.Q. Ipswich 3, 730 feet, 1 inch (Helidon Sandstone).

Remarks: A few specimens have been observed which are identified, specifically, with spores recorded as *Cingutriletes* sp. cf. *C. clavus* by Reiser and Williams, as they conform to the descriptions and illustrations of those authors (Reiser and Williams, 1969, pp. 9, 10; pl. 4, figs. 6, 7).

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Triassic of Raceview Formation, Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Genus CONTIGNISPORITES Dettmann, 1963

Type species: Contignisporites glebulentus Dettmann, 1963.

Contignisporites sp.

Remarks: Two specimens, recorded in assemblages from the Marburg Formation, are similar to spores recorded as *Contignisporites* sp. from the Surat Basin (Reiser and Williams, 1969, p. 12). Insufficient specimens are available for formal taxonomic treatment.

Distribution: Upper Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969); Marburg Formation (this paper).

Genus DENSOSPORITES Berry *emend.* Butterworth, Jansonius, Smith and Staplin, 1964

Type species: Densosporites covensis Berry, 1937.

Densosporites raceviewensis sp. nov.

Plate 3, Figures 9, 10; Plate 4, Figures 1, 2, and 4

Synonym

1970 cf. *Densosporites* sp. de Jersey, 1970b, p. 9; pl. 3, fig. 9.

Diagnosis: Trilete, cingulate, two-layered miospores. Amb convexly subtriangular to subcircular. Diameter (based on 24 measured specimens) 26 to 43 microns. Laesurae, straight or slightly sinuous, extend to, or almost to, equator, without any marked development of lips. Cingulum 2 to 7 microns wide, of uniform width in subcircular specimens, or slightly broader interradially, in subtriangular specimens. Intexine thin, smooth, normally closely attached to exoexine. Distal exoexine smooth, proximal exoexine smooth or faintly punctate. Cingulum smooth, dark in colour, of uniform thickness.

Holotype (*Plate* 4, *Figures* 1, 2—*proximal; distal foci*): Slide S2367, stage co-ordinates 21.8, 98.7; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 82.0.

Locality: G.S.Q. Ipswich 4, 993 feet, 4 inches (Raceview Formation).

Figured specimen (*Plate* 3, *Figure* 9): Slide S2366, stage co-ordinates 24.9, 87.3; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 81.9.

Locality: G.S.Q. Ipswich 4, 993 feet, 4 inches (Raceview Formation).

Figured specimen (*Plate* 3, *Figure* 10): Slide S2338, stage co-ordinates 7.0, 93.5; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 26.3, 86.4.

Locality: G.S.Q. Ipswich 4, 1042 feet, 3 inches Raceview Formation).

Figured specimen (*Plate* 4, *Figure* 4): Slide S2335, stage co-ordinates 14.0, 93.0; diameter 26 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 80.1.

Locality: G.S.Q. Ipswich 4, 1042 feet, 3 inches Raceview Formation).

Variation: Appreciable variation exists in the width of the cingulum, from specimens in which it is relatively narrow (Plate 3, Figure 9) to those with broader cingula, in relation to the spore radius (as in Plate 4, Figure 4). Inter-radial broadening of the cingulum is evident in the holotype (Plate 4, Figures 1 and 2),

which is convexly subtriangular, but not in subcircular specimens (as in Plate 4, Figure 4). The thin intexine is normally difficult to detect, but is evident in the oil-immersion photograph (Plate 3, Figure 9) of a specimen with a widely open trilete rent, in which it has become slightly detached from the exoexine.

Remarks: This species resembles spores assigned to *Stenozonotriletes* (Naumova) Potonié, 1958, such as *S. lycosporoides* (Butterworth & Williams) Smith & Butterworth, 1967, in having a cingulum of uniform thickness and in the width of the cingulum, in proportion to the spore radius. However, it differs from described species of that genus in having a thin intexine and for that reason has been assigned to *Densosporites*. As in the case of *Stenozonotriletes*, no mention is made of a two-layered exine in the diagnosis of *Cingutriletes* Pierce *emend.* Dettman, 1963 (Dettmann, 1963, p. 69). Assignment to *Densosporites* is thus preferred, similarly, to inclusion in this Mesozoic genus.

No close comparison can be made with Palaeozoic species of *Densosporites*. Smooth species of the genus, from Carboniferous sediments, have cingula which are wider, in proportion to the amb radius, and which also differ in tapering equatorially.

Among Australian Mesozoic species, *Cingutriletes clavus* (Balme) Dettmann, 1963, differs in having a thickened area on the distal exine (Dettmann, 1963, p. 69). Spores described as *Cingutriletes* sp. cf. *C. clavus* (Balme) Dettmann by Reiser and Williams (1969, p. 9) have laesurae with thickened lips, which are shorter than those of the Raceview specimens. Other species which are of similar general construction to *D. raceviewensis* are *Stereisporites megastereoides* Pflug, 1953 and *Cingutriletes congruens* Pierce, 1961, but no mention is made of an intexine in the description of either species. The Rhaetic species *Camarozonosporites laevigatus* Schulz, 1967 resembles extreme variants of *D. raceviewensis* in having a cingulum which is broader inter-radially, but the Queensland spores have longer laesurae which lack the thickened lips of *C. laevigatus*.

Distribution: Raceview Formation (de Jersey, 1970b, this paper).

Genus NEVESISPORITES de Jersey & Paten, 1964

Type species: Nevesisporites vallatus de Jersey & Paten, 1964.

Nevesisporites vallatus de Jersey & Paten, 1964

Plate 4, Figure 7

Figured specimen: Slide S2452, stage co-ordinates 23.4, 89.4; diameter 40 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 84.3.

Locality: G.S.Q. Ipswich 5, 267 feet, 9 inches (Marburg Formation).

Distribution: Upper Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); upper Helidon Sandstone, Marburg Formation (this paper).

Genus POLYCINGULATISPORITES Simoncsics & Kedves *emend.* Playford & Dettmann, 1965

Type species: Polycingulatisporites circulus Simoncsics & Kedves, 1961.

Polycingulatisporites crenulatus Playford & Dettmann, 1965

Plate 4, Figure 5

Figured specimen: Slide S2413, stage co-ordinates 17.5, 86.5; diameter 59 microns. Co-ordinates of lower right hand corner of cover glass 23.7, 84.7.

Locality: N.S. 272, 603 feet, 4 inches (Ripley Road Sandstone).

Remarks: Variation in this species has been discussed in detail in a recent paper (de Jersey, 1970b, pp. 10, 11).

Distribution: Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Middle Rhaetian of East Germany (Schulz, 1967); Triassic of Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, this paper); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Polycingulatisporites densatus (de Jersey) Playford & Dettmann, 1965

Plate 4, Figure 3

Figured specimen: Slide S2516, stage co-ordinates 7.3, 86.4; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.2.

Locality: G.S.Q. Ipswich 9, 612 feet, 7 inches (Helidon Sandstone).

Distribution: Jurassic of Walloon Coal Measures, Rosewood Coalfield (de Jersey, 1959); Rhaeto-Liassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Jurassic of Evergreen Formation, Lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Triassic of Mount Crosby Formation (de Jersey and Hamilton, 1965a); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Polycingulatisporites mooniensis de Jersey & Paten, 1964

Plate 4, Figure 8

Figured specimen: Slide S2445, stage co-ordinates 9.8, 93.2; diameter 25 microns. Co-ordinates of lower right hand corner of cover glass 26.3, 83.8.

Locality: G.S.Q. Ipswich 5, 530 feet, 1 inch (Marburg Formation).

Distribution: Precipice Sandstone, Evergreen Formation of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds

(Playford and Cornelius, 1967); Triassic of Raceview Formation, Ripley Road Sandstone, Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1970b, this paper).

Genus TAUROCUSPORITES Stover *emend.* Playford & Dettmann, 1965

Type species: Taurocusporites segmentatus Stover, 1962.

Taurocusporites sp.

Remarks: Playford and Dettmann (1965, p. 146) restricted *Taurocusporites* to "proximally sculptured forms which in other (distal) respects are close to *Polycingulatisporites* Simoncsics & Kedves, 1961". A single specimen observed in the present material has distal thickenings similar to those of *P. crenulatus* Playford & Dettmann, 1965 and also well developed lips, but exhibits conspicuous proximal verrucae. It has accordingly been recorded as "*Taurocusporites sp.*"

Distribution: Helidon Sandstone (this paper).

Subturma PERINOTRILITES Erdtman, 1947

Genus SEMIRETISPORIS Reinhardt, 1962

Type species: Semiretisporis gothae Reinhardt, 1962.

Semiretisporis antiquus (de Jersey) de Jersey, 1970

Remarks: Reference should be made to a recent paper (de Jersey, 1970b, pl. 12) for an account of the morphology of this species.

Distribution: Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Triassic of Moorooka Formation, Brisbane area (de Jersey and Hamilton, 1965b).

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma SCULPTATOMONOLETI Dybová & Jachowicz, 1957

Genus ARATRISPORITES Leschik emend. Playford & Dettmann, 1965

Type species: Aratrisporites parvispinosus Leschik *emend.* Playford, 1965.

Aratrisporites sp. cf. *A. minimus* Schulz, 1967

Plate 4, Figure 12

Figured specimen: Slide S2411, stage co-ordinates 19.9, 91.8; dimensions 41 x 28 microns. Co-ordinates of lower right hand corner of cover glass 25.2, 83.6.

Locality: N.S. 272 (Ipswich), 603 feet, 4 inches (Ripley Road Sandstone).

Remarks: This specimen closely resembles *Aratrisporites minimus,* described by Schulz (1967, p. 592) from the Hettangian of East Germany, in outline, size and in the relatively narrow extension of the outer layer, beyond the inner layer at the equator. However, study of the sculpture with an oil-immersion objective indicates that it consists of very fine coni and grana. The specimen is accordingly compared, rather than identified, with *A. minimus,* which is described as having an infra-granulate or finely punctate exoexine.

Distribution (one specimen): Ripley Road Sandstone (this paper).

Aratrisporites sp. cf. *A. scabratus* Klaus, 1960

Plate 4, Figure 13

Figured specimen: Slide S2523, stage co-ordinates 26.7, 98.1; dimensions 45 x 31 microns. Co-ordinates of lower right hand corner of cover glass 27.4, 83.4.

Locality: G.S.Q. Ipswich 9, 743 feet, 3 inches (Raceview Formation).

Remarks: This specimen is comparable with *Aratrisporites scabratus* described by Klaus (1960, p. 147) from the Karnian of Austria. The finely granulate to conate sculpture is similar to that of the Austrian species, which the Queensland specimen also resembles in size and in the proportions of the inner and outer layers. Because of its somewhat more elongate outline, which differs from the broadly oval to subcircular outline shown in published illustrations of *A. scabratus*, the specimen is not formally identified with that species.

Distribution (one specimen): Raceview Formation (this paper).

Genus POLYPODIISPORITES Potonié & Gelletich ex Potonié, 1956

Type species: Polypodiisporites favus (Potonié) Potonié & Gelletich, 1933.

Polypodiisporites ipsviciensis (de Jersey) Playford & Dettmann, 1965

Distribution: Triassic of Ipswich Coal Measures (de Jersey, 1962, 1970b); Late Triassic of Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Wollar Sandstone, New South Wales (Helby, 1967); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a).

Genus PUNCTATOSPORITES Ibrahim, 1933

Type species: Punctatosporites minutus Ibrahim, 1933.

Punctatosporites walkomi de Jersey, 1933.

Distribution: Triassic of Ipswich Coal Measures (de Jersey, 1962, 1970b); Late Triassic of Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969); Jurassic of Helidon Sandstone (this paper).

Anteturma POLLENITES Potonié, 1931

Turma SACCITES Erdtman, 1947

Subturma MONOSACCITES Chitaley *emend.* Potonié & Kremp, 1954

Infraturma SACCIZONATI Bharadwaj, 1957

Genus ZONALAPOLLENITES Pflug (in Thomson & Pflug), 1953

Type species: Zonalapollenites igniculus Potonié ex Pflug, 1953.

Remarks: Considerable confusion exists in the literature regarding the generic assignment of the species recorded below as *Zonalapollenites dampieri* and *Z. segmentatus*. Concerning the genera *Zonalapollenites* and *Tsugaepollenites,* the position has been recently clarified by Pocock (1968, p. 639) who has indicated that *Zonalapollenites* was validly published in 1953 and that *Tsugaepollenites* was not validated until 1958. Thus *Tsugaepollenites* is regarded as a junior synonym of *Zonalapollenites* Pflug, 1953. This interpretation is followed here; specimens from the Jurassic of the Surat Basin recorded by de Jersey and Paten (1964) and Reiser and Williams (1969) as *Tsugaepollenites dampieri* and *T. segmentatus* are reassigned to *Zonalapollenites.*

One of these species, Z. *dampieri,* was selected as the type species of the genus *Callialasporites* by Sukh Dev (1961, p. 48); proposal of this genus served to separate Mesozoic species from the Tertiary type species of *Zonalapollenites,* Z. *igniculus*. Later workers have assigned both Z. *dampieri* and Z. *segmentatus* to *Callialasporites*. However it is considered here that, on the available evidence, the differences between these two species and Z. *igniculus* are insufficient to justify placing them in a separate genus and they are accordingly retained in *Zonalapollenites*.

In a recent paper, Singh and Kumar (1969) have placed both *Zonalapollenites dampieri* and *Z. segmentatus* in *Tsugaepollenites*. These authors were evidently not aware of, and did not take into account, the evidence brought forward by Pocock (1968).

Zonalapollenites dampieri Balme, 1957

Plate 4, Figure 10; Plate 5, Figure 6

Figured specimen (*Plate* 4, *Figure* 10)*:* Slide S2484, stage co-ordinates 16.0, 90.2; overall diameter 56 microns, diameter of corpus 46 microns. Co-ordinates of lower right hand corner of cover glass 25.0, 82.0.

Locality: G.S.Q. Ipswich 5, 184 feet, 6 inches (Marburg Formation).

Figured specimen (*Plate* 5, *Figure* 6)*:* Slide S2486, stage co-ordinates 20.8, 86.4; overall diameter 69 microns, diameter of corpus 50 microns. Co-ordinates of lower right hand corner of cover glass 24.0, 83.0.

Locality: G.S.Q. Ipswich 5, 89 feet, 5 inches (Marburg Formation).

Remarks: Reiser and Williams (1969, p. 13) found evidence for a gradation from *Zonalapollenites segmentatus,* through *Z. dampieri* to *Z trilobatus*. They did not merge these forms into one species, since the material examined was at or just above the level of the first appearance of the genus in the Surat Basin, and it is possible that the three types become more clearly differentiated in younger sediments. Nevertheless, the suggestion of inter-gradation among these species provides evidence for assignment to the same genus (*Zonalapollenites*), and against placing them in different genera, as has been done by some authors. The specimens figured conform to Balme's description of the species (1957, p. 32). One of them (Plate 5, Figure 6) has a faint (vestigial) trilete mark. This feature has previously been reported in *Z. dampieri* by Balme (1957, p. 32) and Dettmann, (1963, p. 100).

Distribution: Widely distributed in Jurassic and Cretaceous sediments. In a European sequence, which is accurately dated by associated marine faunas, Schulz (1967, p. 593) records the first appearance of the species in the upper Toarcian (uppermost Liassic). Queensland records: Jurassic sequence of Surat Basin, first appearing in Upper Evergreen Formation (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Walloon Coal Measures, Marburg Formation (de Jersey, 1959, 1963, this paper); Cretaceous of Eromanga Basin (Haskell, 1968).

Zonalapollenites segmentatus Balme, 1957

Plate 4, Figure 11

Figured specimen: Slide S2486, stage co-ordinates 6.3, 84.0; overall diameter 59 microns, diameter of corpus 51 microns. Co-ordinates of lower right hand corner of cover glass 24.0, 83.0.

Locality: G.S.Q. Ipswich 5, 89 feet, 5 inches (Marburg Formation).

Remarks: The specimen figured is identified with *Zonalapollenites segmentatus,* on the basis of Balme's original description and figures (1957, p. 33, pl. 9, figs. 93, 94). Evidence for a gradation between this species and *Z. dampieri* has been mentioned above under that species.

Distribution: Widely distributed in Jurassic sediments. Queensland records: Jurassic sequence of Surat Basin, first appearing in upper Evergreen Formation (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Walloon Coal Measures, Marburg Formation (de Jersey, 1959, 1963, this paper).

Subturma DISACCITES Cookson, 1947

Remarks: Bisaccate pollen grains are abundant in some of the assemblages examined, particularly those from the Raceview Formation, which are in many cases dominated by grains of the *Pteruchus* type. Many of these grains are poorly preserved; difficulties inherent in effecting specific, or even generic circumscription of a large proportion of them have recently been discussed (de Jersey, 1970b, p. 14). Furthermore it seems likely that such precise taxonomic studies will have little, if any stratigraphic application in the section investigated. Accordingly, apart from certain distinctive species, recorded below, the remaining bisaccate grains have been listed simply as "Disaccites (indet.)" in the assemblages recorded.

Genus ALISPORITES Daugherty, 1941

Type species: Alisporites opii Daugherty, 1941.

Alisporites sp. cf. *A. grandis* (Cookson) Dettmann, 1963

Remarks: Two specimens, each in an assemblage from the Marburg Formation, are similar to a specimen recorded as *Alisporites* sp. cf. *A. grandis* by Reiser and Williams (1969, pl. 5, fig. 18) and are close to haploxylonoid types of *A. grandis* illustrated by Cookson (1953, pl. 2, fig. 41), Balme (1957, pl. 10, fig. 110) and Haskell (1968, pl. 1, fig. 2).

Distribution: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Marburg Formation (this paper).

Alisporites lowoodensis de Jersey, 1963

Plate 5, Figure 4

Figured specimen: Slide S2516, stage co-ordinates 23.3, 97.0; total span 54 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 83.2.

Locality: G.S.Q. Ipswich 9, 612 feet, 7 inches (Helidon Sandstone).

Remarks: This species is fairly widespread in samples from the Helidon Sandstone and Marburg Formation and has also been recorded in two assemblages from the Raceview Formation.

Distribution: Jurassic of Marburg Formation, Helidon Sandstone (de Jersey, 1963, this paper); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Late Triassic of Raceview Formation (de Jersey, 1970b, this paper).

Alisporites similis (Balme) Dettmann, 1963

Plate 5, Figure 5

Figured specimen: Slide S2393, stage co-ordinates 17.9, 100.7; total span 58 microns. Co-ordinates of lower right hand corner of cover glass 25.7, 86.4.

Locality: G.S.Q. Ipswich 3, 575 feet, 10 inches (Helidon Sandstone).

Remarks: The morphology of this species has been recently clarified by Haskell (1968, p. 218). In the present study it has been observed sporadically in assemblages from the Helidon Sandstone and Marburg Formation. Reiser and Williams (1969, p. 14) recorded specimens from the Precipice Sandstone, Evergreen Formation and lower Hutton Sandstone of the Surat Basin as *Alisporites* sp. cf. *A. similis.*

Distribution: Upper Jurassic of Western Australia (Balme, 1957); Lower Cretaceous of south-eastern Australia (Dettmann, 1963); Lower Cretaceous of Eromanga Basin (Haskell, 1968); Lower Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Genus INDUSIISPORITES Leschik, 1955

Type species: Indusiisporites velatus Leschik, 1955.

Indusiisporites parvisaccatus (de Jersey) de Jersey, 1963

Distribution: Jurassic of Walloon Coal Measures (de Jersey, 1959); Marburg Formation, Helidon Sandstone (de Jersey, 1963, this paper); Jurassic sequence of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic Razorback Beds (Playford and Cornelius, 1967); Late Triassic of Ripley Road Sandstone (this paper).

Genus PLATYSACCUS Naumova ex Potonié & Klaus, 1954

Type species: Platysaccus papilionis Potonié & Klaus, 1954.

Platysaccus queenslandi de Jersey, 1962

Distribution: Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964, 1970b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Tasmania (Playford, 1965); Triassic of Cacheuta Formation, Argentina (Jain, 1968); Triassic and Jurassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Jurassic of Helidon Sandstone (this paper).

Genus PODOCARPIDITES Cookson ex Couper, 1953

Type species: Podocarpidites ellipticus Cookson, 1947.

Podocarpidites sp. cf. *P. ellipticus* Cookson, 1947

Plate 5, Figure 7

Figured specimen: Slide S2467, stage co-ordinates 23.5, 89.0; total span 74 microns. Co-ordinates of lower right hand corner of cover glass 25.8, 84.0.

Locality: G.S.Q. Ipswich 5, 204 feet, 9 inches (Marburg Formation).

Remarks: The specimen figured exhibits the characteristic features of *Podocarpidites ellipticus,* as detailed by Haskell (1968, p. 221), except that the sacci are relatively longer, in proportion to the length of the corpus, than in typical specimens of the species figured by Cookson (1947, pl. 13, figs. 5-7), Balme (1957, pl. 9, fig. 104, pl. 10, figs. 105-107) and Haskell (1968, pl. 1, fig. 7).

A similar specimen, with relatively large sacci, from the Precipice Sandstone of the Surat Basin, was also recorded as *Podocarpidites* sp. cf. *P. ellipticus* by Reiser and Williams (1969, pl. 6, fig. 3). Apart from the specimen figured, specific identification or comparison has not been attempted for other specimens of *Podocarpidites* recorded in the present study, which are, in general, unfavourably compressed or otherwise poorly preserved.

Distribution: Precipice Sandstone of Surat Basin (Reiser and Williams, 1969); Marburg Formation (this paper).

Genus VITREISPORITES Leschik *emend.* Jansonius, 1962

Type species: Vitreisporites signatus Leschik, 1955.

Vitreisporites microsaccus de Jersey, 1964

Distribution: Triassic of Blackstone Formation, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper).

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Distribution: Widespread in Mesozoic sediments. Queensland records: Jurassic of Walloon Coal Measures, Marburg Formation, Helidon Sandstone (de Jersey, 1959, 1963, this paper); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Cretaceous of Eromanga Basin (Haskell, 1968); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Blackstone Formation, Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, this paper).

Genus TRISACCITES Cookson & Pike, 1954

Type species: Trisaccites microsaccatus (Couper) Couper, 1960.

Remarks: Haskell (1968, p. 234) distinguished *Trisaccites* from *Podosporites* by its having pendent sacci that do not extend beyond the corpus equator and are thickest between the centre and distal edge of the saccale areas. This grouping of the species is followed here.

Trisaccites variabilis (Dev) Haskell, 1968

Plate 5, Figure 1

Figured specimen: Slide S2399, stage co-ordinates 23.1, 94.2; diameter of corpus 51 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 85.5.

Locality: G.S.Q. Ipswich 3, 153 feet, 3 inches (Marburg Formation).

Remarks: The persistent first appearance of this species, within the Helidon Sandstone, is regarded as significant from the biostratigraphic aspect.

Distribution: Jurassic Jabalpur Series of Pradesh, India (Dev, 1961); Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); upper Helidon Sandstone, Marburg Formation (this paper).

Turma ALETES Ibrahim, 1933

Subturma AZONALETES Luber *emend.* Potonié & Kremp, 1954

Infraturma PSILONAPITI Erdtman, 1947

Genus INAPERTUROPOLLENITES (Pflug) ex Thomson & Pflug. *emend.* Potonié, 1966

Type species: Inaperturopollenites dubius (Potonié & Venitz) Thomson & Pflug *emend.* Potonié, 1966.

Inaperturopollenites fuscus (de Jersey, 1962) comb. nov.

1962 *Pilasporites fuscus* de Jersey, p. 14, pl. 6, figs. 4, 5

Remarks: Jain (1968, p. 42) has recently emended the generic diagnosis of *Pilasporites* Balme & Hennelly, 1956 on the basis of evidence he has brought forward, which indicates that grains of *Pilasporites* have a large distal polar opening ("pore") and are not differentially thickened. This interpretation is followed here. Accordingly the species *Pilasporites fuscus* described by the writer from the Ipswich Coal Measures (de Jersey, 1967, p. 14) is here transferred as a new combination to *Inaperturopollenites,* as its exine is alete, without any indication of a distal polar thickening. In the present study, *I. fuscus* has been recorded in one of the Raceview assemblages.

Distribution: Triassic of Ipswich Coal Measures (de Jersey, 1962); Aberdare Conglomerate (de Jersey, 1970b); Raceview Formation (this paper).

Inaperturopollenites turbatus Balme, 1957

Plate 5, Figure 3

Figured specimen: Slide S2483, stage co-ordinates 22.9, 96.9; diameter 71 microns. Co-ordinates of lower right hand corner of cover glass 25.0, 83.0.

Locality: G.S.Q. Ipswich 5, 159 feet, 9 inches (Marburg Formation).

Remarks: Balme (1957, p. 31) considered that the darker central area in this species resulted from differential thickening. Other workers, such as Schulz (1967, p. 593) have transferred the species to *Callialasporites,* because they regarded the darker area as a "central body". However *Inaperturopollenites turbatus* appears to be distinct from *Callialasporites* in exhibiting no evidence of the presence of saccus attachments and in having a different pattern of secondary folding. It is provisionally retained in *Inaperturopollenites* until there is definite proof of the presence of an inner layer, from studies of thin sections of the exine or other conclusive evidence.

Distribution: Widely distributed in Jurassic sediments. Schulz (1967, p. 593) recorded the species as first appearing in the Toarcian (uppermost Liassic), in a microfloral sequence in East Germany, which is accurately dated by associated marine faunas. In France it was recorded by Rioult (1965, p. 295) from the Rhaetic onwards. Queensland records: Jurassic sequence of Surat Basin (first appearance in upper Evergreen Formation) (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Marburg Formation (de Jersey, 1963, this paper).

Inaperturopollenites spp. (indet.)

Remarks: Smooth or faintly ornamented grains, assigned to this genus, are present in most of the assemblages studied. Apart from specimens assigned to the species recorded above, specific identification has not been attempted.

Infraturma GRANULONAPITI Cookson, 1947

Genus ARAUCARIACITES Cookson ex Couper, 1953

Type species: Araucariacites australis Cookson, 1947.

Araucariacites fissus Reiser & Williams, 1969

Distribution: Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Hutton Sandstone, Marburg Formation (this paper).

Araucariacites spp. (indet.)

Remarks: Under this heading are recorded poorly preserved specimens; with sculpture of grana, rather than coni, as in *Conaletes.*

Genus CONALETES Reinhardt & Schön, 1967

Type species: Conaletes apiculatus Reinhardt & Schön, 1967.

Conaletes sp.

Plate 5, Figure 2

Figured specimen: Slide S2356, stage co-ordinates 13.9, 85.6; diameter 49 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 83.6.

Locality: G.S.Q. Ipswich 4, 745 feet, 5 inches (Helidon Sandstone).

Remarks: The specimen figured has a comprehensive sculpture, dominantly of coni, with minor spinae; the exine exhibits secondary folds. It is representative of alete grains assigned to the genus. Problems inherent in specific differentiation of Queensland specimens of *Conaletes* have been discussed recently (de Jersey, 1970b, p. 16); insufficient well preserved specimens have been observed in the present study to provide any further evidence on specific identification.

Distribution: Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, this paper); Jurassic of Helidon Sandstone, Marburg Formation (this paper).

Genus DUPLICISPORITES Leschik *emend.* Klaus, 1960

Type species: Duplicisporites granulatus Leschik, 1955.

Duplicisporites sp. A.

Remarks: One specimen, identifiable with this species, recently recorded from the Ipswich-Bundamba sequence (de Jersey, 1970b, p. 17) has been observed in one of the Raceview assemblages.

Distribution: Blackstone Formation, Raceview Formation (de Jersey, 1970b, this paper).

Infraturma CIRCUMPOLLINI Pflug *emend.* Klaus, 1960
Genus CLASSOPOLLIS Pflug *emend.* de Jersey & Paten, 1964

Type species: Classopollis classoides Pflug *emend.* Pocock & Jansonius, 1961.

Remarks: The interpretation of Pocock and Jansonius, who regarded *Classopollis classoides* as the valid type species of this genus, is followed here. They point out (1961, pp. 439-442) that although the specific epithets *reclusus* and *torosus* were published prior to *classoides,* there is no certainty that grains described under those names are specifically identifiable with *C. classoides.* Comparison is rendered difficult by the lack of detail in published illustrations and by the brief descriptions of the earlier taxa; thus a conservative interpretation seems desirable. Some later workers, e.g. Couper (1589, pp. 156, 157), Chaloner (1962, pp. 19-23), Geiger and Hopping (1968, p. 33) have regarded *C. classoides* and *C. torosus* as identical and have assigned specimens to *C. torosus* on grounds of synomymy; such specimens, following the interpretation of Pocock and Jansonius, would be recorded under the name *C. classoides.*

The concept of the generic circumscription of *Classopollis,* which is followed here, is that of de Jersey and Paten (1964, p. 11). This interpretation makes provision for including in the genus species with smooth equatorial girdles, such as *C. simplex* (Danzé-Corsin & Laveine) Reiser & Williams, as well as species with equatorial striations, such as *C. classoides.* This concept of the genus was opposed by Boltenhagen (1968, p. 30), who advocated restriction of *Classopollis* to species with equatorial striations. However, in the present study, specimens of *C. classoides* have been observed in which the equatorial striations are broken up into parallel rows of more or less discrete sculptural elements. Such specimens are suggestive of a transition between *C. classoides* and *C. simplex* and in any case indicate that too much significance should not be attached to the presence of continuous equatorial striations as a generic characteristic. Apart from simplifying the generic determination of such specimens, apparently intermediate between *C. classoides* and *C. simplex,* the interpretation of the genus, followed here, is of considerable practical utility in classifying grains preserved in polar view. Such grains comprise the vast majority of specimens of *Classopollis* observed in Queensland Jurassic assemblages. If a more restricted interpretation of the genus were followed, only a small proportion of the grains (those preserved in equatorial view) could be identified, generically, with certainty.

Classopollis classoides Pflug *emend.* Pocock & Jansonius, 1961

Plate 6, Figures 1, 2, 3 and 5

Figured specimen (*Plate* 6, *Figure* 1)*:* Slide S2377, stage co-ordinates 10.6, 103.4; equatorial diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 25.6, 84.0.

Locality: G.S.Q. Ipswich 3, 1189 feet (Helidon Sandstone).

Figured specimen (*Plate* 6, *Figure* 2)*:* Slide S2404, stage co-ordinates 13.2, 94.9; dimensions 35 microns (equatorial) x 31 microns (polar). Co-ordinates of lower right hand corner of cover glass 24.9, 85.0.

Locality: G.S.Q. Ipswich 3, 130 feet, 9 inches (Marburg Formation).

Figured specimen (*Plate* 6, *Figure* 3)*:* Slide S2346, stage co-ordinates 11.1, 83.7; dimensions 38 microns (equatorial) x 30 microns (polar). Co-ordinates of lower right hand corner of cover glass 22.7, 82.5.

Locality: G.S.Q. Ipswich 4, 435 feet, 5 inches (Helidon Sandstone).

Figured specimen (*Plate* 6, *Figure* 5)*:* Slide S2518, stage co-ordinates 13.7, 92.4; dimensions 38 microns (equatorial) x 38 microns (polar). Co-ordinates of lower right hand corner of cover glass 26.0, 84.1.

Locality: G.S.Q. Ipswich 9, 612 feet, 7 inches (Helidon Sandstone).

Remarks: The typical features of this species are shown by the specimens figured in polar and equatorial view (Plate 6, Figures 1 and 2). As indicated above, such specimens are suggestive of a transition to *Classopollis simplex*. One such specimen is that illustrated (in equatorial view) in Plate 6, Figure 3, which shows the equatorial striations breaking up into discrete elements. In many specimens the intexine is not readily apparent; it is, however evident in one of the figured specimens (Plate 6, Figure 5) in which it has contracted away from the exoexine. This specimen also shows partial breaking up of the equatorial striations into discrete elements.

Distribution: Very widely distributed in sediments from Rhaetic to Tertiary in age. Geiger and Hopping (1968, p. 33) point out that this species has been confused with *Gliscopollis meyeriana* by some earlier writers; this would explain reported occurrences of *C. classoides* in pre- Rhaetic strata. It has been recorded from the Jurassic and Cretaceous of the Surat and Eromanga Basins in Queensland. Records in south-eastern Queensland are: Marburg Formation (de Jersey, 1963, this paper); Helidon Sandstone (this paper). The species is also present in an assemblage from sediments in G.S.Q. Ipswich No. 1, assigned to the Ripley Road Sandstone, but considered to represent a level which is stratigraphically higher than the top of the type section of that formation.

Classopollis simplex (Danzé-Corsin & Laveine) Reiser & Williams, 1969

Plate 6, Figures 4 and 8

Figured specimen (*Plate* 6, *Figure* 4)*:* Slide S2349, stage co-ordinates 16.8, 93.6; dimensions 33 microns (equatorial) x 21 microns (polar). Co-ordinates of lower right hand corner of cover glass 22.4, 29.9.

Locality: G.S.Q. Ipswich 4, 639 feet, 11 inches (Helidon Sandstone).

Figured specimen (*Plate* 6, *Figure* 8)*:* Slide S2448, stage co-ordinates 13.0, 95.1; diameter 25 microns. Co-ordinates of lower right hand corner of cover glass 24.3, 86.6.

Locality: G.S.Q. Ipswich 5, 375 feet, 1 inch (Marburg Formation).

Remarks: The specimen figured in polar view (Plate 4, Figure 8) is a typical representative of the species, with its smooth, thickened equatorial girdle and infra-granulate distal exine. The other figured specimen illustrates in equatorial view, the thickened equatorial girdle. This specimen is suggestive of transition to *Classopollis classoides* in that the equatorial girdle exhibits infra-granulate sculpture. However the sculptural elements are discrete, not fused to form bands (striations). While the specimen is thus regarded as being more appropriately assigned to *C. simplex*, it may be considered, along with specimens such as that figured in Plate 6, Figure 3, as forming a series suggestive of transition to *C. classoides*.

The species *Gliscopollis tersus* (Norris) Volkheimer, 1968 resembles *C. simplex* in size, in having a thickened equatorial girdle and in other features and (since it was proposed in 1965) may be a junior synonym. However the identity of the two species cannot be definitely established as there is as yet no evidence for the presence of an intexine in *G. tersus*.

Another species with a smooth or slightly infra-sculptured exine is *Gliscopollis meyeriana* (Klaus) Venkatachala, 1966. It differs from *C. simplex* in lacking a thickened equatorial girdle and an intexine; the latter species may have been derived from *G. meyeriana* by development of these features.

Distribution: Jurassic of France (Briche, Danzé-Corsin and Laveine, 1963; Levet-Carette, 1964, 1965); Queensland records: Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Hill, Playford and Woods, 1966; Reiser and Williams, 1969); Jurassic Razorback Beds (Playford and Cornelius, 1967); Jurassic Helidon Sandstone, Marburg Formation (this paper).

Genus DISCISPORITES Leschik *emend.* de Jersey, 1964

Type species: Discisporites niger Leschik, 1955.

Discisporites psilatus de Jersey, 1964.

Plate 6, Figure 10

Figured specimen: Slide S2410, stage co-ordinates 20.4, 93.4; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 24.7, 84.9.

Locality: N.S. 272, 603 feet, 4 inches (Ripley Road Sandstone).

Distribution: Triassic of Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper).

Genus GLISCOPOLLIS Venkatachala, 1966

Type species: Gliscopollis meyeriana (Klaus) Venkatachala, 1966.

Gliscopollis meyeriana (Klaus) Venkatachala, 1966

Plate 6, Figures 6, 7 and 11

Figured specimen (*Plate* 6, *Figures* 6, 7*—proximal, distal foci*)*:* Slide S1827, stage co-ordinates 19.7, 100.1; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 25.0, 84.1.

Locality: G.S.Q. Ipswich 1, 384 feet, 6 inches (Ripley Road Sandstone).

Figured specimen (*Plate* 6, *Figure* 11)*:* Slide S2375, stage co-ordinates 14.2, 88.4; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 85.8.

Locality: G.S.Q. Ipswich 3, 1189 feet (Helidon Sandstone).

Remarks: Specimens of *Gliscopollis meyeriana,* recorded in the material studied, range from 21 to 39 microns in equatorial diameter. The species differs from *G. tersus* (Norris) Volkheimer, 1968, described by Norris (1965, pp. 260, 261) and Volkheimer (1968,

pp. 365, 366) in having an exine of uniform thickness, not thickened equatorially. *Classopollis simplex* also has a smooth exine, but is distinguished by its thickened equatorial girdle and by the differentiation of the exine into intexine and exoexine, a feature not observed in *G. meyeriana.*

Distribution: Karnian, Norian and Rhaetian of Austria (Klaus, 1960); Rhaetian of Hungary (Venkatachala and Góczán, 1964); Middle and Upper Keuper and Liassic of East Germany (Schulz, 1966, 1967); Norian and Rhaetian of West Germany and the Netherlands, Rhaetian of England (Geiger and Hopping, 1968); Triassic of Aberdare Conglomerate, Raceview Formation and Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Jurassic of Helidon Sandstone (this paper) .

Turma PLICATES Naumova *emend.* Potonié, 1960

Subturma POLYPLICATES Erdtman, 1952

Genus EQUISETOSPORITES Daugherty *emend.* Pocock & Jansonius, 1964

Type species: Equisetosporites chinleana Daugherty, 1941.

Remarks: As indicated previously (de Jersey, 1968, p. 20) the writer supports the use of this generic name for dispersed pollen grains of this Ephedroid type. Accordingly the species *Ephedripites tortuosus* Mädler, 1964 to assigned to *Equisetosporites* as a new combination.

Equisetosporites sp. cf. *E. tortuosus* (Mädler, 1964) comb. nov.

Plate 6, Figure 9

Figured specimen: Slide S2410, stage co-ordinates 18.2, 97.1; dimensions 38 x 21 microns. Co-ordinates of lower right hand corner of cover glass 24.8, 84.8.

Locality: N.S. 272, 603 feet, 4 inches (Ripley Road Sandstone).

Remarks: The specimen figured is somewhat smaller than grains of *Equisetosporites tortuosus* (Mädler) comb. nov., described by Mädler (1964b, p. 194, pl. 3, fig. 17) and Schulz (1967, p. 604) but appears to have ridges arranged in a similar pattern. As it is the only specimen of this type observed it is compared, rather than identified, with *E. tortuosus.*

Distribution of E. tortuosus: Liassic of Germany (Mädler, 1964; Schulz, 1966, 1967).

Subturma MONOCOLPATES Wodehouse, Iversen & Troels-Smith, 1953

Genus CAMEROSPORITES Leschik *emend.* Clarke, 1965

Type species: Camerosporites secatus Leschik, 1955.

Camerosporites clarkei nom. nov.

Synonymy:

1964 *Discisporites verrucosus* de Jersey, pp. 12, 13; pl. 2, figs. 13, 15, 16.

1967 *Discisporites verrucosus* de Jersey, in de Jersey and Hamilton, p. 19, pl. 9, fig. 11.

1970 *Camerosporites verrucosus* (de Jersey) de Jersey comb. nov. in de Jersey, 1970b, p. 18, pl. 6, figs. 4-7.

Remarks: The name *Camerosporites verrucosus* (de Jersey) de Jersey 1970, proposed as a new combination for this species (de Jersey, 1970b, p. 18) is a later homonym of *Camerosporites verrucosus* Mädler 1964, described by Mädler (1964, p. 174) from the Middle Keuper of Germany. Accordingly, in conformity with Articles 55 and 64 of the International Code of Botanical Nomenclature (1966) the new specific epithet *clarkei* is proposed for this species. This new specific name has reference to Dr. R. F. A. Clarke, who re-interpreted the morphology of *Camerosporites* (Clarke, 1965, p. 313).

Distribution: Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Jurassic of Helidon Sandstone (this paper).

Genus CEREBROPOLLENITES Nilsson *emend.* Singh & Kumar, 1969

Type species: Cerebropollenites macroverrucosus (Thiergart) Schulz, 1967.

Remarks: Pocock states (1968, p. 640) that *Cerebropollenites* "includes strongly convolute grains with sexine and nexine tightly appressed. These species form a distinct and significant morphological group, separable from *Zonalapollenites*". Likewise Schulz (1967, p. 603) distinguishes *Cerebropollenites* from *Tsugaepollenites* (= *Zonalapollenites*) on the basis of the different sculpture and presence of a sulcus in Nilsson's genus. These views are supported here; the sculpture, presence of a sulcus and close attachment of the layers of exine are all features which enable distinction from *Zonalapollenites.*

In Nilsson's original diagnosis (1958, p. 72) the genus is described as inaperturate. Clearly this is inappropriate in view of the presence of a sulcus, and accordingly the emendation of Singh and Kumar (1969, p. 87) is adopted here. (Schulz (1967, p. 603) regarded the genus as monosulcate (not inaperturate) but made no formal emendation of the diagnosis).

Cerebropollenites sp. cf. *C. macroverrucosus* (Thiergart) Schulz, 1967

Plate 6, Figures 13, 14

Figured specimen (*Plate* 6, *Figures* 13, 14—*proximal, distal foci*)*:* Slide S2390, stage co-ordinates 20.7, 94.0; diameter 48 microns, sulcus 20 x 16 microns. Co-ordinates of lower right hand corner of cover glass 25.6, 87.5.

Locality: G.S.Q. Ipswich 3, 575 feet, 10 inches (Helidon Sandstone).

Remarks: Schulz (1967, p. 603) has discussed the morphology and taxonomy of *Cerebropollenites macroverrucosus*; his interpretation is supported here. The specimen figured (Plate 6, Figures 13, 14) is closely comparable with this species, as described and illus-

trated by Nilsson (1958), Danzé-Corsin and Laveine (1963) and Schulz (1967). The sculpture of the proximal polar region is particularly reminiscent of a specimen figured by Danzé-Corsin and Laveine (1963, pl. 8, fig. 13b). The only feature in which there is some apparent difference is in the lower profile of the projections at the equatorial margin of the Queensland specimen; this may be an effect due to greater compression in preservation. Because of this difference, which may or may not be significant and because only one specimen has been observed, it is compared, rather than identified, with *C. macroverrucosus*.

Distribution of C. macroverrucosus: Liassic, Dogger of East Germany (Thiergart, 1949; Schulz and Mai, Schulz, 1966, 1967); Jurassic and Lower Cretaceous of Great Britain (Couper, 1958); Liassic of Sweden (Nilsson, 1958); Liassic of Poland, Hungary (Schulz, 1967); Infraliassic of France (Briche, Danzé-Corsin and Laveine, 1963, Levet-Carette, 1964, 1965).

Cerebropollenites sp. cf. *C. thiergartii* Schulz, 1967

Plate 6, Figure 12

Figured specimen: Slide S2516, stage co-ordinates 15.8, 100.0; diameter 51 microns, sulcus 23 x 21 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 83.2.

Locality: G.S.Q. Ipswich 9, 612 feet, 7 inches (Helidon Sandstone).

Remarks: Cerebropollenites thiergartii differs from *C. macroverrucosus* in having smaller, more compact verrucae. The specimen figured conforms to the specific diagnosis (Schulz, 1967, p. 604), but because detailed comparison of the sculpture has not been possible, on the basis of the published illustrations, it has not been formally identified with the European species.

Distribution of C. thiergartii: Liassic of East Germany and Poland (Schulz, 1967).

Genus CYCADOPITES Wodehouse ex Wilson & Webster, 1946

Type species: Cycadopites follicularis Wilson & Webster, 1946.

Cycadopites granulatus (de Jersey) de Jersey, 1964.

Distribution: Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1962, 1964, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Jurassic of Marburg Formation (this paper).

Cycadopites magnus Herbst, 1965

Plate 2, Figure 11

Figured specimen: Slide S2364, stage co-ordinates 23.2, 88.6; dimensions 86 x 28 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 85.6.

Locality: G.S.Q. Ipswich 4, 993 feet, 4 inches (Raceview Formation).

Remarks: Two specimens in one of the Raceview assemblages conform to the description and figures of this species (Herbst, 1965, p. 149, pl. 2, figs. 22, 23). The species is distinguished by its relatively large size and presence of prominent folds or thickenings adjacent to the colpus.

Distribution: Upper Triassic Los Rastros Formation of Argentina (Herbst, 1965); Raceview Formation (this paper).

Cycadopites nitidus (Balme) de Jersey, 1964

Distribution: Widely distributed in the Mesozoic of Australia. Queensland records: Jurassic of Walloon Coal Measures, Marburg Formation, Helidon Sandstone (de Jersey, 1959, 1963, this paper); Jurassic of Precipice Sandstone, Evergreen Formation, Helidon Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Triassic of Ipswich Coal Measures, Bundamba Group (de Jersey, 1964, 1970b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a).

Cycadopites sp. cf. *C. potoniei* Bharadwaj & Singh, 1964

Plate 2, Figure 10

Figured specimen: Slide S2406, stage co-ordinates 17.6, 93.1; dimensions 94 x 33 microns. Co-ordinates of lower right hand corner of cover glass 25.7, 83.5.

Locality: N.S. 272, 1128 feet, 9 inches (Ripley Road Sandstone).

Remarks: The specimen figured is representative of a few large grains which are similar in all other features to *Cycadopites potoniei* Bharadwaj & Singh, 1964 but are somewhat more elongate, the length : breadth ratio being about 3 : 1, as compared with 2 : 1 quoted by Bharadwaj and Singh (1964, p. 39). Accordingly these specimens are compared, rather than identified with that species. They differ from grains of *C. grandis* de Jersey and Hamilton, 1967 (de Jersey and Hamilton, 1967, p. 19) in being more spindle-shaped and in having more pointed extremities.

Distribution: Triassic of Raceview Formation, Ripley Road Sandstone (this paper); Jurassic of Marburg Formation (this paper).

Turma POROSES Naumova *emend.* Potonié, 1960

Subturma MONOPORINES Naumova, 1939

Genus PERINOPOLLENITES Couper, 1958

Type species: Perinopollenites elatoides Couper, 1958.

Perinopollenites elatoides Couper, 1958

Plate 4, Figures 6, 9

Figured specimen (*Plate* 4, *Figure* 6)*:* Slide S2349, stage co-ordinates 16.0, 96.8; diameter 46 microns. intexine 35 microns. Co-ordinates of lower right hand corner of cover glass 27.5, 79.9.

Locality: G.S.Q. Ipswich 4, 639 feet, 11 inches (Helidon Sandstone).

Figured specimen (*Plate* 4, *Figure* 9)*:* Slide S2347, stage co-ordinates 14.7, 91.0; diameter 33 microns, intexine 23 microns. Co-ordinates of lower right hand corner of cover glass 26.8, 84.6.

Locailty: G.S.Q. Ipswich 4, 435 feet, 5 inches (Helidon Sandstone).

Distribution: Widespread in Jurassic and Lower Cretaceous sediments of Europe and Canada, Rhaeto-Liassic of Poland (Orlowska-Zwolinska, 1966); Rhaetic and Liassic of East Germany (Schulz, 1966). Queensland records: Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Ripley Road Sandstone, Helidon Sandstone, Marburg Formation (de Jersey, 1963, this paper).

Acritarcha

Remarks: Acritarchs, assigned to the genera *Baltisphaeridium, Micrhystridium* and *Veryhachium,* have been recorded in three of the assemblages from the Marburg Formation, penetrated in G.S.Q. Ipswich 5. The samples which yielded these acritarchs came from a section containing chamositic oolite, which is regarded as stratigraphically equivalent to a section in the Evergreen Formation of the Surat Basin, with sediments of similar lithology. Samples from the latter sequence also contain acritarchs (Reiser and Williams, 1969, p. 21). The stratigraphic significance of these occurrences, associated with these oolitic sediments, is discussed in a later section of this paper.

Incertae Sedis

Genus Circulisporites de Jersey *emend.* Norris, 1965

Type species: Circulisporites parvus de Jersey *emend.* Norris, 1965.

Circulisporites parvus de Jersey *emend.* Norris, 1965

Distribution: Recorded from the Permian and Mesozoic of Australia, South Africa and Antarctica. Queensland records: Triassic of Ipswich Coal Measures (de Jersey, 1962, 1970b); Late Triassic of Bundamba Group (de Jersey, 1964); Triassic of Tingalpa Formation, Brisbane area (de Jersey and Hamilton, 1965b); Jurassic of Marburg Formation (de Jersey, 1963, this paper); Jurassic of Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

MICROFLORAL SEQUENCE AND CORRELATION IN THE SECTION STUDIED

As indicated in the Stratigraphic Discussion above, the sections penetrated in G.S.Q. Ipswich 3, 4, and 5 can be correlated on the basis of lithological evidence (see figure 2). The complete sequence intersected in these holes has a stratigraphic thickness of about 2430 feet. (Because of the slight magnitude of the regional dip to the south, stratigraphic and vertical thicknesses can be approximately equated). The distribution of genera and species is shown diagrammatically in Figure 3, which is a composite distribution diagram based on the complete thickness of sediments penetrated.

Samples from the Esk Beds, at the base of this composite sequence, were barren. Assemblages from the overlying section came from sediments correlated, on lithological evidence, with the Raceview Formation. They were derived from samples between the depths of 991 and 1169 feet in G.S.Q. Ipswich 4. In all these assemblages bisaccate pollen grains (mainly of the *Pteruchus* type) are abundant or dominant; *Classopollis, Lycopodiumsporites austroclavatidites* and *Perinopollenites elatoides* are absent. Species present include *Foveosporites moretonensis, Gliscopollis meyeriana, Lycopodiumsporites rosewoodensis, Polycingulatisporites crenulatus* and *P. mooniensis.* This association is characteristic of the Raceview Formation (de Jersey, 1970b, pp. 19-22, fig. 2); the composition of the assemblages thus supports lithological correlation of this section with that unit.

Similar assemblages are recorded from a section of Raceview-like sediments, penetrated between 742 and 995 feet in G.S.Q. Ipswich 9. The presence of this attenuated representative of the Raceview Formation in two separate areas (the Lowood and Helidon areas) indicates that it may well be of significant areal extent in the subsurface of the region between Helidon and Ipswich.

Overlying the Raceview Formation in G.S.Q. Ipswich 4 is the Helidon Sandstone; it is about 1180 feet in thickness in the section penetrated by G.S.Q. Ipswich 3, 4 and 5. Study of the distribution diagram (Figure 3) shows that there is a marked change in the assemblages; the level at which this change takes place substantially coincides with the lithological boundary between the formations. A distinctive feature of the Helidon assemblages is the presence, usually in abundance, of *Classopollis classoides,* a species which is absent from the Raceview microflora. Coinciding with the introduction of *Classopollis,* the proportion of bisaccate pollen grains is markedly reduced. Other species which are introduced include *Ceratosporites helidonensis, Lycopodiumsporites austroclavatidites, L. semimuris* and *Perinopollenites elatoides*; their abrupt introduction, together with the disappearance of certain Raceview species, favours the view that there was a time interval between the Raceview and Helidon microfloras. This view is supported by other evidence, discussed below.

The Helidon Sandstone is much thicker than the Precipice Sandstone, a unit of similar lithology in the Surat Basin. Typical sections of the latter, in the U.K.A. Moonie 3 Well and in D.R.D. 6 (Reiser and Williams, 1969, Text. fig. 3) are approximately 270 and 300 feet in thickness respectively. Assuming roughly similar rates of deposition, the greater thickness of the Helidon Sandstone indicates a longer time range for the sediments of this formation. Comparison of the Precipice and Helidon assemblages also supports the view that deposition of the latter unit extended over a longer time interval. Assemblages from the basal part

of the Helidon Sandstone, in G.S.Q. Ipswich 3 and 4, are lacking in certain species, including in particular *Antulsporites varigranulatus* and *Trisaccites variabilis* (= *Podosporites* sp. of Reiser and Williams, 1969), which are present in the basal part of the Precipice Sandstone (Reiser and Williams, 1969, Figures 4, 5). Moreover they contain *Ceratosporites helidonensis,* a distinctive species which has not been recorded in the Precipice assemblages. From these features of the microfloras it is concluded that the section, about 500 feet in thickness, at the base of the Helidon Sandstone in G.S.Q. Ipswich 3 and 4 is older than the Precipice Sandstone.

At higher levels *C. helidonensis* is absent, and with the gradual introduction of Precipice species, the miospore populations become increasingly similar to those from the Surat Basin. Assemblages which are very similar to those of the Precipice Sandstone came from depths of 531 feet 1 inch and 575 feet 10 inches in G.S.Q. Ipswich 3, and a section of similar thickness to the average Precipice sequence can be selected in this upper part of the Helidon Sandstone, including these levels in G.S.Q. Ipswich 3. On this basis the correlation of the Precipice Sandstone with a section in the upper part of the Helidon Sequence is indicated below in Table 1.

In G.S.Q. Ipswich 9 (near Helidon) the Helidon Sandstone is appreciably thinner than in the area around Lowood, its thickness being about 650 feet in this hole. In this section there are fewer shale beds than in the sections of the formation penetrated in G.S.Q. Ipswich 3 and 4 and only two assemblages are recorded. However the presence of *Ceratosporites helidonensis* in one of them (from 612 feet, 7 inches) and the absence of *Antulsporites varigranulatus* and *Trisaccites variabilis* from the other (from 696 feet, 8 inches) provide evidence for the presence of the lower, pre-Precipice portion of the Helidon sequence in this area also, although its thickness is evidently considerably less than in the Lowood area.

Slightly higher in the sequence, the first appearance of *Nevesisporites vallatus* is of biostratigraphic significance. In the Surat Basin the first appearance of this species has been used to define the base of a subzone (Reiser and Williams, 1969, p. 19). In sections in D.R.D. 6 and 12, studied by those authors, it first appears in the uppermost 100 feet of the Precipice Sandstone. The earliest record of the species, in the Helidon sequence, is in an assemblage from 575 feet, 10 inches in G.S.Q. Ipswich 3; the top of the Helidon Sandstone is at a depth of 200 feet in this hole. By equating this first appearance with the base of the *Nevesisporites vallatus* Subzone in the sections studied by Reiser and Williams, the top of the Helidon Sandstone is equated with a level about 250 to 350 feet above the Precipice-Evergreen boundary in the Surat Basin. This correlation is indicated below in Table 1.

The next major change in the microfloral sequence is brought about by the appearance of *Zonalapollenites,* notably *Z. dampieri* and *Z. segmentatus.* The first appearance of this genus was used by Reiser and Williams (1969, p. 19) to define the top of their *Classopollis classoides* Zone, and also the top of the *Nevesisporites vallatus* Subzone within it. In the Surat Basin the top of this zone (and subzone) is in the Evergreen Formation, at or near the base of the Boxvale Sandstone or Westgrove Ironstone Member(where the Boxvale Sandstone is absent). In the sections studied by Reiser and Williams its level ranged from about 80 to 210 feet below the top of the Evergreen Formation. The first record of *Zonalapollenites,* in the Lowood sequence, is in an assemblage from 234 feet, 2 inches in G.S.Q. Ipswich 5. This is about 800 feet above the base of the Marburg Formation. Consequently the Evergreen-Hutton boundary is equated (from the aspect of time equivalence) with a level about 900 feet above the base of the Marburg Formation. This relationship is shown in Table 1.

In the Surat Basin the uppermost part of the Evergreen Formation, overlying the level of the first appearance of *Zonalapollenites,* is characterized by the presence of beds of chamositic oolite. In this part of the sequence, also, varying proportions of acritarchs are present in the microfloral assemblages. Reiser and Williams point out (1969, p. 21) that while this lithology is suggestive of marine origin, acritarchs have been found associated with marine, brackish and freshwater deposits. Apart from a few arenaceous foraminifera from the acritarch-bearing interval at one locality, there are no other records of foraminifera or other marine macro- or microfossils. Accordingly Reiser and Williams concluded (loc. cit.) that "although a widespread change of environment is indicated at this interval, it is uncertain whether or not there was a true marine incursion".

This pattern of distribution of acritarchs and oolite beds is repeated in the Marburg Formation. In G.S.Q. Ipswich 5 acritarchs are present in the assemblages from samples at 184 feet, 6 inches, 159 feet, 9 inches and 89 feet, 5 inches and beds of oolite, respectively 1 inch and 5 inches in thickness, occur at depths of 166 feet, 1 inch and 185 feet, 3 inches (A.R.G. Gray, pers. comm.). From this evidence, taken in conjunction with that of occurrences of oolite reported by Woods (1947, pp. 12, 13) from the Brighton-Pine River area, it seems probable that the change of environment noted by Reiser and Williams was even more widespread than reported by those authors, and that it took place over a distance of at least 250 miles (i.e., from the Roma area to the present coastline). A similar conclusion has been reached by R. J. Paten (pers. comm.) on the basis of the distribution of other samples containing acritarchs and oolite beds at other localities.

In both the Marburg and Evergreen Formations, beds of oolite are confined to relatively narrow intervals in the sequence and it seems likely that this oolitic facies is relatively continuous over the area concerned. The presence of oolite in G.S.Q. Ipswich 5 thus enables evidence bearing on the possibility of diachronism of this oolite-bearing section, to be assessed. This can be done by comparison of the levels at which *Zonalapollenites* first appears, in relation to the oolite-bearing intervals. In the Evergreen Formation of the Surat Basin, Reiser and Williams (1969, Fig. 5) record the

first appearance of *Zonalapollenites* (=*Tsugaepollenites*) at about 60 feet below the oolitic section in D.R.D. No. 6. (Selection of this hole for comparison with the Moreton Basin is more appropriate than use of other stratigraphic holes, which intersected the Boxvale Sandstone, a unit known locally in the northern Surat Basin, which wedges out to the east and is not represented in the Moreton Basin). In the Marburg Formation, *Zonalapollenites* makes its first appearance in G.S.Q. Ipswich 5, about 50 feet below the oolitic section. When the vertical spacing of the samples is taken into account, the intervals below the oolitic section in each case (50 and 60 feet) are so similar as to indicate that the latter is relatively isochronous, between D.R.D. 6 and G.S.Q. Ipswich 5. Further evidence from other sections is desirable, but assuming that the introduction of *Zonalapollenites* constitutes a reliable time marker, it seems likely that deposition of the oolitic sediments took place at about the same time over their entire areal extent.

In Table 1 the stratigraphic positions of sections in the Ipswich and Ripley Road areas, in relation to the Helidon-Marburg sequence, are also indicated. Evidence from the former area is based on N.S. 272 (Ipswich), core from which constitutes the type sections of the Raceview Formation and Ripley Road Sandstone (Staines, 1964, p. 34). Microfloral assemblages from the Raceview Formation and Aberdare Conglomerate in this hole have been discussed recently (de Jersey, 1970b); this investigation has now been extended to samples from the Ripley Road Sandstone. A particularly rich and varied assemblage has been obtained from a sample from a depth of 603 feet, 4 inches in this hole. This assemblage lacks *Classopollis,* which is a constant and usually abundant component of the Helidon assemblages. In this respect it resembles assemblages previously recorded from the Ripley Road Sandstone (de Jersey, 1964); the absence of *Classopollis* in the type section of the Formation and in other sections equivalent to it indicates a pre-Helidon age for this part of the sequence. This Ripley Road assemblage includes species such as *Ceratosporites helidonensis, Lycopodiumsporites austroclavatidites* and *Perinopollenites elatoides,* the presence of which indicates that the assemblage is intermediate between the Raceview and Helidon microfloras. The occurrence of *Ceratosporites helidonensis,* in particular, supports the view that the top of this type section of the Ripley Road Sandstone is relatively close, in time, to the basal part of the Helidon Sandstone, as has been shown in Table 1.

The other stratigraphic hole, G.S.Q. Ipswich 1, was drilled to the southeast, in the Ripley Road area, to explore sediments above the type section of the Ripley Road Sandstone, which in N.S. 272 is overlain by Tertiary strata. This objective was achieved as, while assemblages from the lower part of the section in this hole are similar to those from the type section of the formation, one from a higher sample (192 feet, 1 inch) contains a significant proportion of *Classopollis* and is closely comparable with those from the basal part of the Helidon Sandstone. The uppermost part of the Ripley Road section in this hole has accordingly been equated, in Table 1, with the basal part of the Helidon Sandstone. There is an apparent discrepancy in thickness between the Ripley Road sections in N.S. 272 and G.S.Q. Ipswich 1, in that while these sections are about the same thickness, the top part of the latter has penetrated younger sediments. However these differences in thickness are considered to be an effect of faulting, indicated by the occurrence of steeply-dipping strata and slickensiding in part of the section (near the Raceview-Ripley Road boundary) in G.S.Q. Ipswich 1. Such faulting could lead to elimination of part of the section and render inaccurate any determination of stratigraphic thickness.

On the basis of the correlations shown in Table 1, the geographical distribution of the formations concerned can be related to a major structural feature, the West Ipswich "fault" or West Ipswich Structure of Allen, Staines and Wilson (1960, pp. 259, 260). This is a zone of steeply dipping rocks of varying ages traceable for many miles both north and south of Ipswich. The structure was first observed in the West Ipswich area, where disturbed, steeply-dipping sediments of the Ipswich Coal Measures and Bundamba Group, and sub-horizontal strata of the Walloon Coal Measures, are in juxtaposition. The correlations made indicate that, while sediments of the Raceview Formation and Ripley Road Sandstone, over 1000 feet in total thickness, were being deposited on the eastern side of this structure, only an attenuated version of the Raceview Formation, about 200 feet in thickness, was laid down on the western side. (The latter conclusion is based on the sections penetrated in G.S.Q. Ipswich 4 and 9). Furthermore no sediments equivalent to the upper part of the Ipswich Coal Measures (the Tivoli, Cooneana and Blackstone Formations) have been found on the western side of this structure. Consequently it is suggested that the West Ipswich Structure delineates the eastern margin of the Esk Rift, and that this structural feature had a profound influence on sedimentation in the region in Late Triassic time.

It is presumed that, except for a brief interval, during which an attenuated extension of the Raceview Formation was deposited, the region west of this structural line was a high area being subjected to erosion during the latter part of the Late Triassic. To the east of this structural line, the evidence indicates that continuous sedimentation took place, the sediments represented comprising successively the Aberdare Conglomerate, Raceview Formation and Ripley Road Sandstone, passing conformably upwards into equivalents of the Helidon Sandstone, which on the evidence of surface mapping, are in turn succeeded by equivalents of the Marburg Formation and Walloon Coal Measures. If the sections studied are representative, it is evident that only in a restricted portion of south-eastern Queensland, including the area east of the West Ipswich Structure, is there a continuous conformable sequence through from the Raceview Formation to equivalents of the Marburg Formation and Walloon Coal Measures.

AGE OF THE MICROFLORAS

In a recent paper (de Jersey, 1970b, pp. 21, 22) microfloral evidence on the age of the Aberdare Conglomerate and Raceview Formation has been discussed. From a comparison of assemblages from these formations with the Triassic microfloral sequence in Europe, they were regarded as Late Triassic (Rhaetian or Norian). This comparison was based on the discovery of European species of restricted range in the Queensland assemblages and on evidence that their patterns of distribution show fairly close similarities in both the Queensland and European successions. The wide distribution of such species is in conformity with the view that provincialism was much less significant in Late Triassic and Early Jurassic floras than, for example, those of Late Cretaceous and Tertiary age (Tschudy, 1969, p. 117). In particular it is noteworthy that three widespread species—*Gliscopollis meyeriana, Classopollis classoides* and *Zonalapollenites dampieri*—appear in the same order in both central European and Queensland sequences; this parallelism provides evidence for a broadly-based correlation.

Extending the above comparison to assemblages from the type section of the Ripley Road Sandstone and from equivalent levels in G.S.Q. Ipswich 1, it is evident that they are also of Late Triassic aspect. Thus they contain *Gliscopollis meyeriana,* but are lacking in *Classopollis*; also present are *Perinopollenites elatoides* and *Polycingulatisporites crenulatus,* which first appear in the Rhaetic of central Europe (Schulz, in Döring *et al.,* 1966, Table 5e). (The morphology and synonymy of the latter species has been recently discussed—de Jersey, 1970b, pp. 10, 11). The Rhaetic aspect of these Ripley Road assemblages is further strengthened by the presence in one of them (from 483 feet, 7 inches in G.S.Q. Ipswich 1) of *Zebrasporites interscriptus.* This species, although its European range extends from late Karnian to Liassic (Schulz, 1967, p. 589; Geiger and Hopping, 1968, p. 32) is a characteristic component of Rhaetian microfloras and rare or absent in assemblages from overlying and underlying sediments. Indeed, its presence was regarded by Geiger and Hopping (1968, p. 12) as a feature distinguishing the Rhaetic from overlying Jurassic strata. Accordingly the type section of the Ripley Road Sandstone and the equivalent section in G.S.Q. Ipswich No. 1 have been shown as Late Triassic in Table 1.

The Helidon Sandstone and uppermost Ripley Road Sandstone in G.S.Q. Ipswich 1 are regarded as probably Early Jurassic on the basis of the presence, in abundance of *Classopollis classoides.* This is a somewhat arbitrary criterion of Jurassic age, as while this species appears in some European sections in the Liassic (e.g. Geiger and Hopping, 1968, p. 7), in others it is known from sediments as old as Rhaetian. However the assignment of these sediments to the Liassic is supported by the Rhaetic aspect of microfloras from the type section of the Ripley Road Sandstone and its equivalents, which as shown in Table 1, are overlain by sediments correlated with the basal Helidon Sandstone. Further evidence for a Liassic age, at least for the upper part of the Helidon Sandstone, is provided by the presence of a specimen of *Cerebropollenites,* closely comparable with *C. macroverrucosus,* in an assemblage from 575 feet, 10 inches in G.S.Q. Ipswich 3. In a European sequence, accurately dated by associated marine faunas, this species first appears in the early Liassic (Schulz, 1967, p. 603). These conclusions on the age of the Helidon Sandstone are indicated by recording it as Rhaeto-Liassic in Table 1, thus allowing for the possibility of the basal Helidon sediments being of Rhaetic age.

At a higher level, *Zonalapollenites dampieri* makes its first appearance near the middle of the Marburg Formation, at a level correlated with its first appearance in the upper Evergreen Formation of the Surat Basin. In Europe the most precisely dated record of the initial appearance of this species is that of Schulz (1967, p. 593) who recorded it from the Toarcian (uppermost Liassic) onwards. By equating these initial appearances the Marburg Formation, and equivalent strata in the Surat Basin, are regarded as Liassic, although it is possible that the uppermost Marburg sediments and, in the Surat Basin, the upper Hutton Sandstone, may extend into the Middle Jurassic.

These conclusions regarding ages of the formations are shown diagrammatically in Table 1, below. This table illustrates the hiatus in deposition at the base of the Helidon Sandstone in the Lowood area and below the Precipice Sandstone of the Surat Basin, the youngest sediments underlying the latter being those of the Middle Triassic Moolayember Formation. Data now available indicate that this time break at or near the base of the Jurassic is a characteristic feature of the Mesozoic record over most of southern Queensland. It seems likely that the only part of the State in which continuous deposition from Late Triassic to Early Jurassic took place is a restricted area of south-eastern Queensland, to the east of the West Ipswich Structure. In this area, as discussed in the preceding section, a continuous conformable sequence appears to exist from the Aberdare Conglomerate, Raceview Formation and Ripley Road Sandstone, upwards into sediments equivalent to the Helidon Sandstone, Marburg Formation and Walloon Coal Measures. This is the only area in eastern Australia, where there is evidence for the existence of a continuous sedimentary sequence extending from Late Triassic to Middle Jurassic, thus spanning the System boundary.

SURAT BASIN (D.R.D. 1, 6, 12; U.K.A. Moonie 1, 3).	MORETON BASIN (G.S.Q. Ipswich 3, 4, 5)	IPSWICH AREA (N.S. 272 Ipswich)	RIPLEY ROAD AREA (G.S.Q. Ipswich 1)	AGE
HUTTON SANDSTONE	MARBURG FORMATION		("Marburg -type" sandstone in outcrop)	RHAETO-LIASSIC
EVERGREEN FORMATION				
PRECIPICE SANDSTONE	HELIDON SANDSTONE			
		RIPLEY ROAD SANDSTONE (type section)	RIPLEY ROAD SANDSTONE	LATE TRIASSIC
	RACEVIEW FMN.	RACEVIEW FORMATION (type section)	RACEVIEW FORMATION	
		Aberdare Conglomerate		

Table 1 — Showing correlation (based on miospore assemblages) and suggested ages of formations studied.

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PLATE 1

(All photographs approximately ×1000)

Figure 1 —*Cyathidites australis* Couper, 1953 (equatorial focus).

Figure 2 —*Anapiculatisporites pristidentatus* Reiser and Williams, 1969 (equatorial focus).

Figure 3 —*Cyathidites minor* Couper, 1953 (equatorial focus).

Figure 4 —*Apiculatisporis globosus* (Leschik) Playford and Dettmann, 1965 (equatorial focus).

Figure 5 —*Anapiculatisporites dawsonensis* Reiser and Williams, 1969 (distal-equatorial focus).

Figure 6 —*Foraminisporis tribulosus* Playford and Dettmann, 1965 (proximal focus).

Figure 7 —*Apiculatisporis taroomensis* Reiser and Williams, 1969 (distal-equatorial focus).

Figure 8 —*Ceratosporites helidonensis* sp. nov. (distal-equatorial focus).

Figure 9 —*Ceratosporites helidonensis* sp. nov. (Holotype, distal-equatorial focus).

Figure 10—*Ceratosporites helidonensis* sp. nov. (proximal focus).

Figure 11—*Ceratosporites helidonensis* sp. nov. (distal focus, same specimen as Figure 10).

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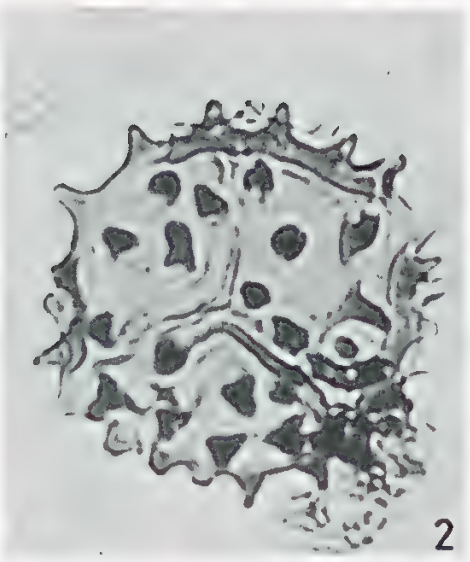
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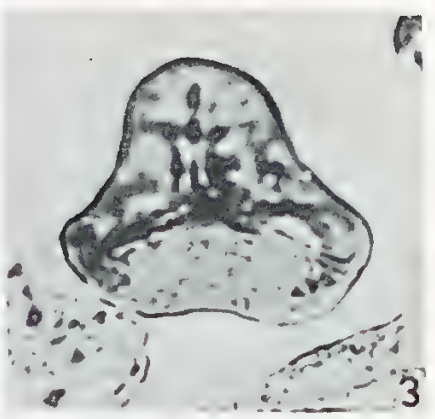
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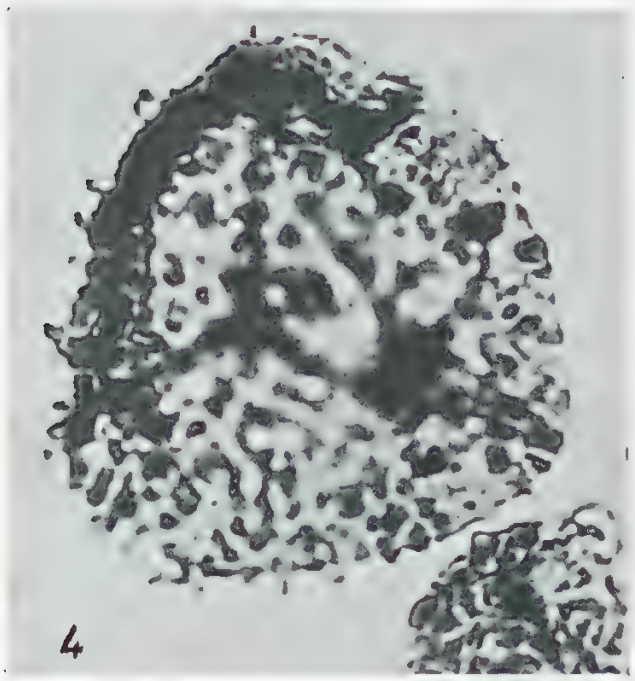
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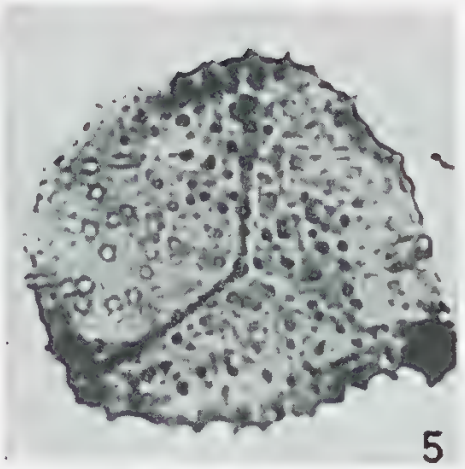
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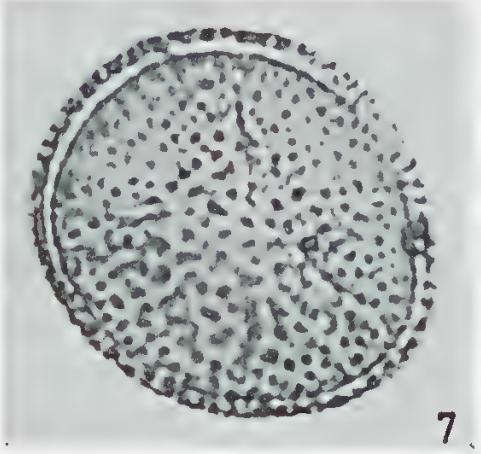
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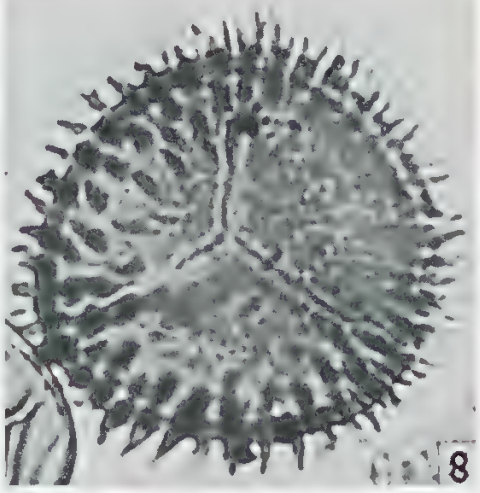
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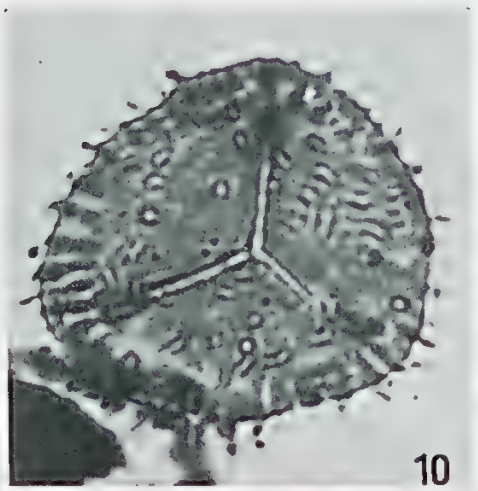
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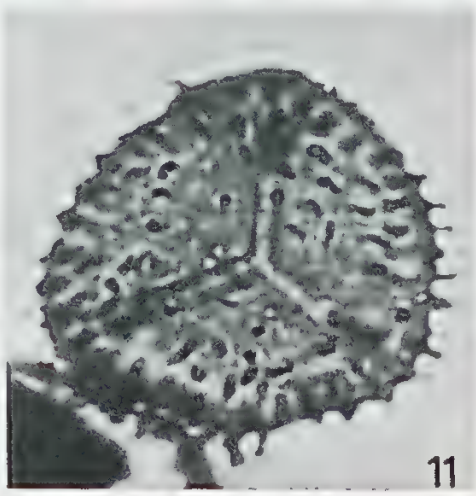
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PLATE 1

PLATE 2

(All photographs approximately ×1000)

Figure 1 —*Ceratosporites helidonensis* sp. nov. (distal-equatorial focus).

Figure 2 —*Conbaculatisporites* sp. A (median focus).

Figure 3 —*Neoraistrickia taylorii* Playford and Dettmann, 1965 (median focus).

Figure 4 —*Neoraistrickia elongata* Reiser and Williams, 1969 (equatorial focus).

Figure 5 —*Neoraistrickia elongata* Reiser and Williams, 1969 (proximal focus, same specimen as Figure 4).

Figure 6 —*Duplexisporites problematicus* (Couper) Playford and Dettmann, 1965 (distal focus).

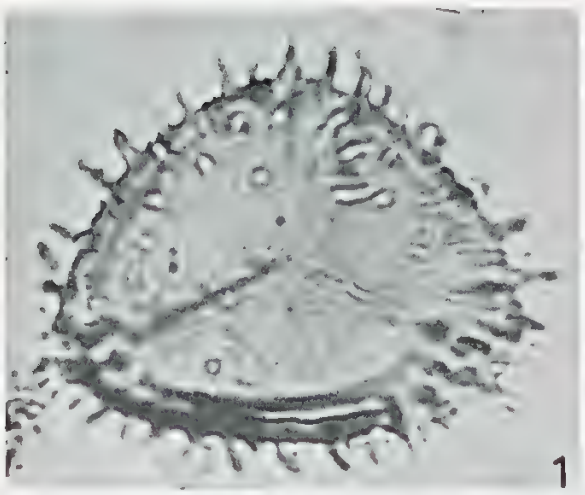
Figure 7 —*Annulispora folliculosa* (Rogalska) de Jersey, 1959 (distal focus).

Figure 8 —*Antulsporites varigranulatus* (Levet-Carette) Reiser and Williams, 1969 (distal focus).

Figure 9 —*Lycopodiacidites* sp. cf. *L. kuepperi* Klaus, 1960 (median focus).

Figure 10—*Cycadopites* sp. cf. *C. potoniei* Bharadwaj and Singh, 1964 (median focus).

Figure 11—*Cycadopites magnus* Herbst, 1965 (median focus).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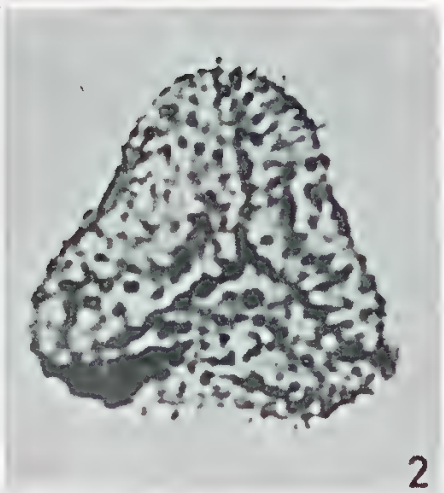
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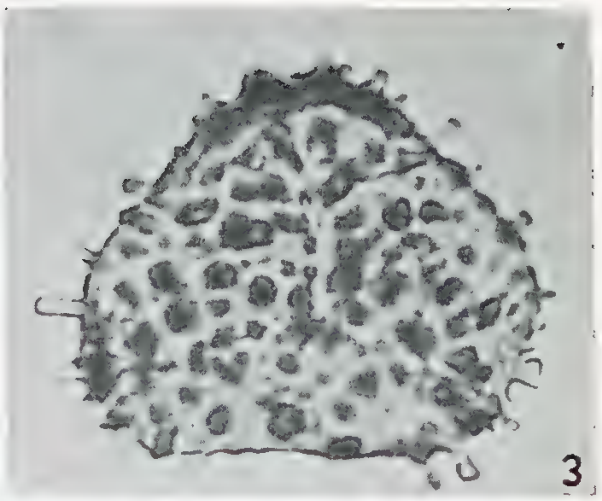
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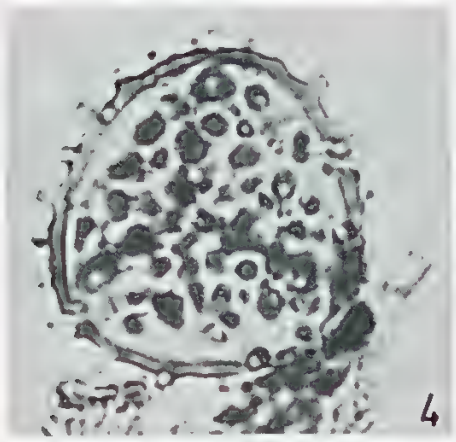
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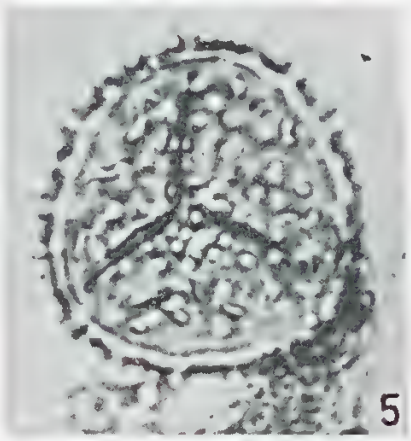
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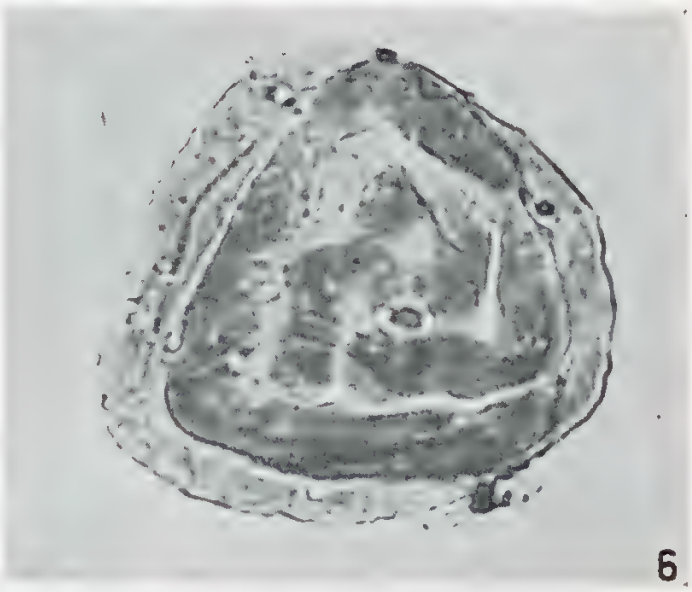
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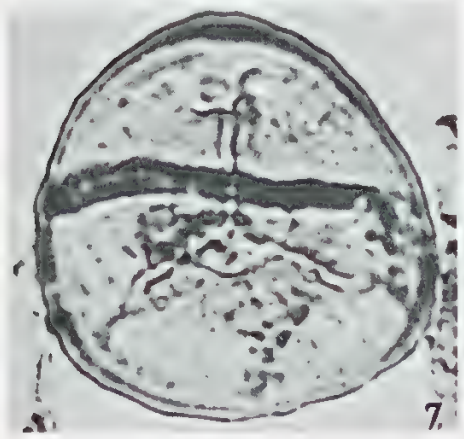
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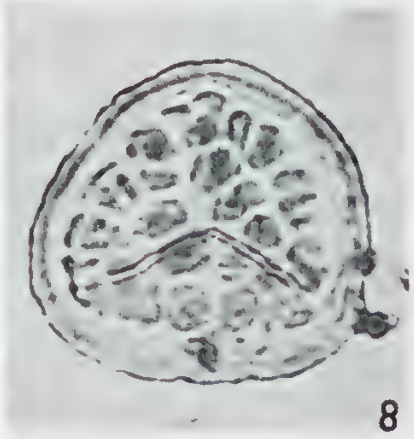
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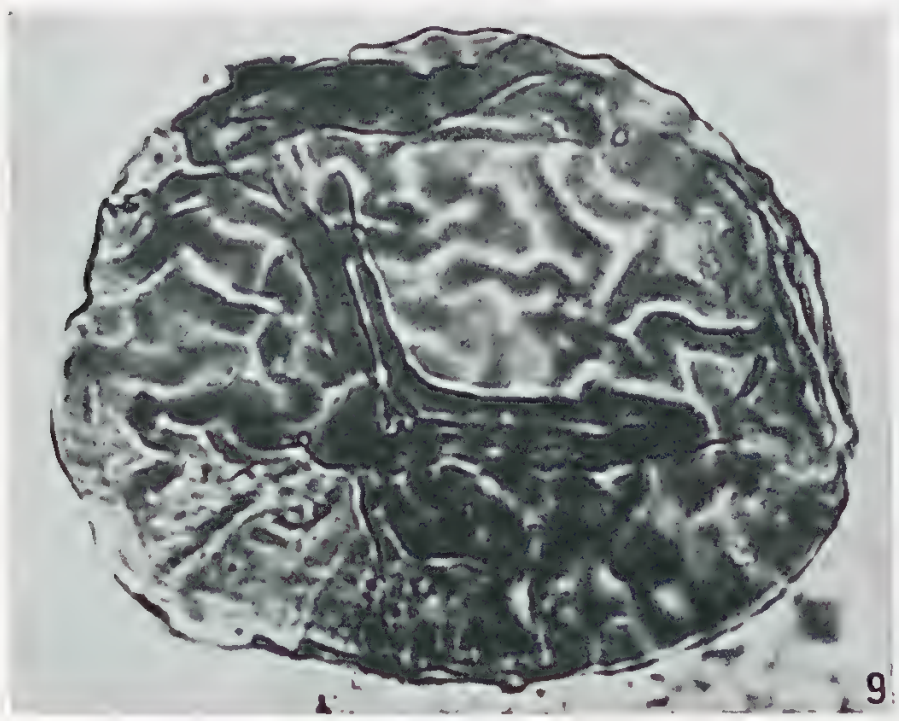
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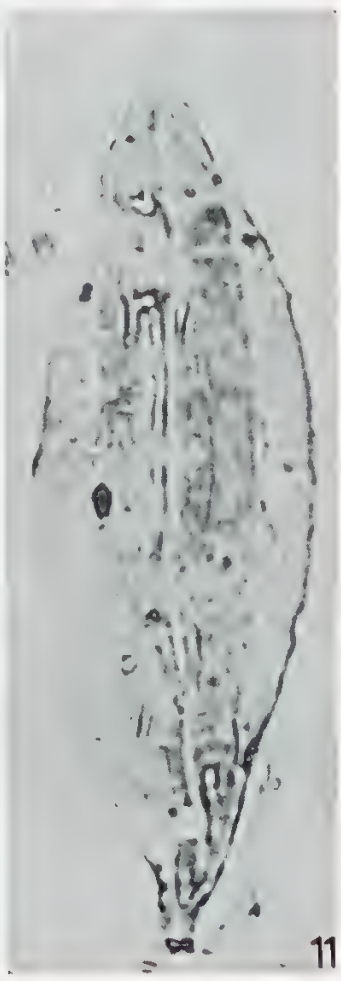
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PLATE 2

PLATE 3
(All photographs approximately ×1000)

Figure 1 —*Lycopodiumsporites austroclavatidites* (Cookson) Potonié, 1956 (proximal facies).

Figure 2 —*Lycopodiumsporites austroclavatidites* (Cookson) Potonié, 1956 (distal focus, same specimen as Figure 1).

Figure 3 —*Lycopodiumsporites semimuris* (Danzé-Corsin and Laveine) Reiser and Williams, 1969 (equatorial focus).

Figure 4 —*Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, 1963 (distal focus).

Figure 5 —*Lycopodiumsporites rosewoodensis* (de Jersey) de Jersey, 1963 (proximal focus, same specimen as Figure 4).

Figure 6 —*Zebrasporites interscriptus* (Thiergart) Klaus, 1960 (median focus).

Figure 7 —*Annulispora microannulata* de Jersey, 1962 (equatorial focus).

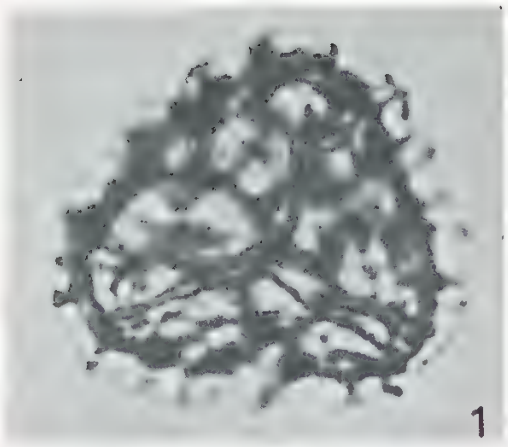
Figure 8 —*Cingutriletes* sp. cf. *C. clavus* (Balme) Dettmann, 1963 (proximal focus).

Figure 9 —*Densosporites raceviewensis* sp. nov. (median focus, showing thin intexine).

Figure 10—*Densosporites raceviewensis* sp. nov. (proximal focus).

Figure 11—*Trilobosporites antiquus* Reiser and Williams, 1969 (proximal focus).

Figure 12—*Ischyosporites marburgensis* de Jersey, 1963 (equatorial focus).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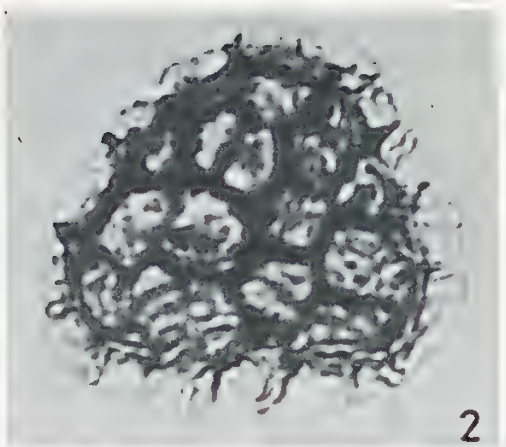
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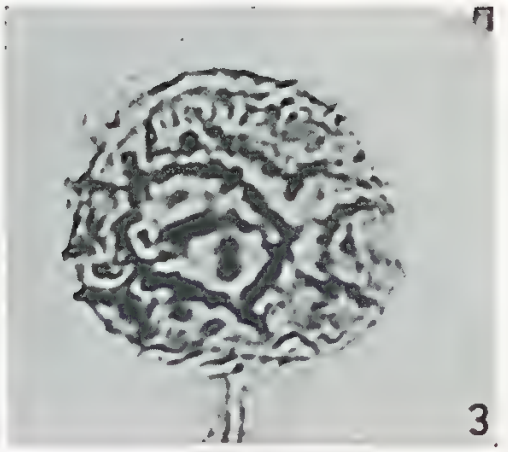
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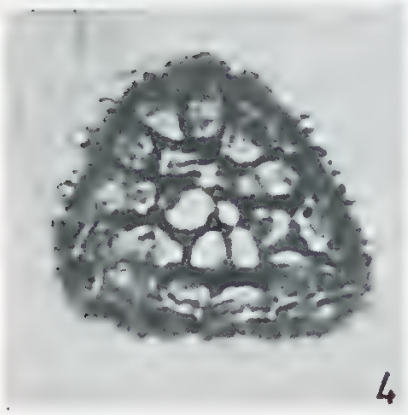
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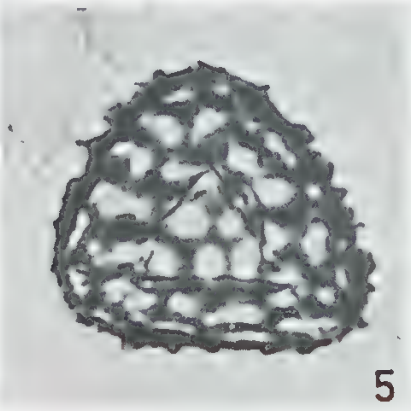
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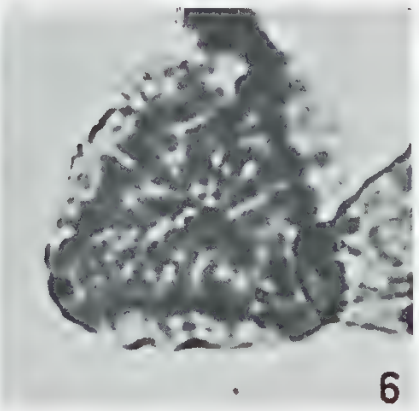
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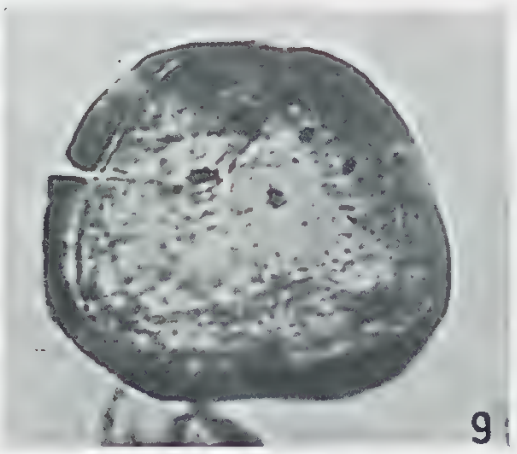
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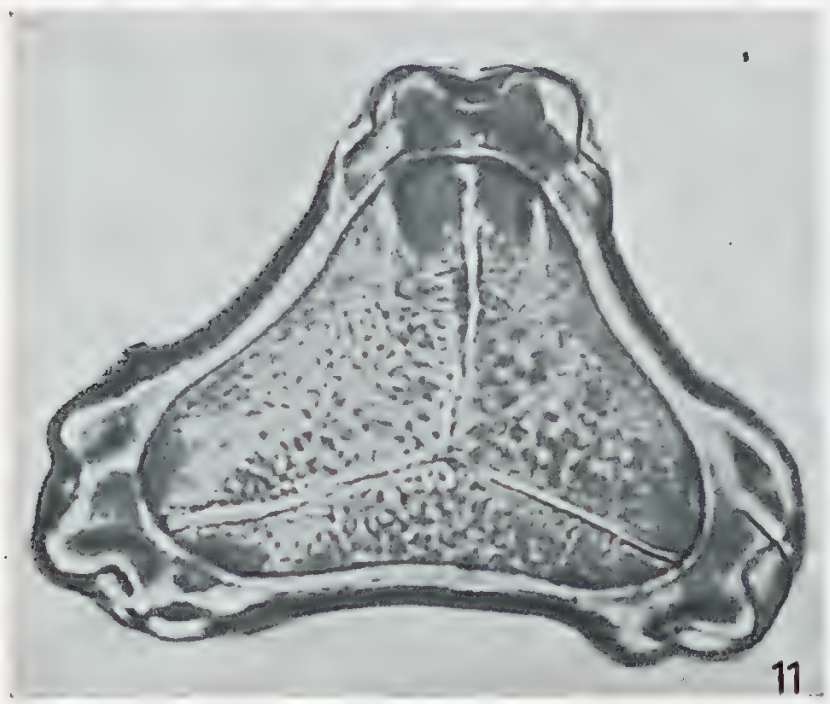
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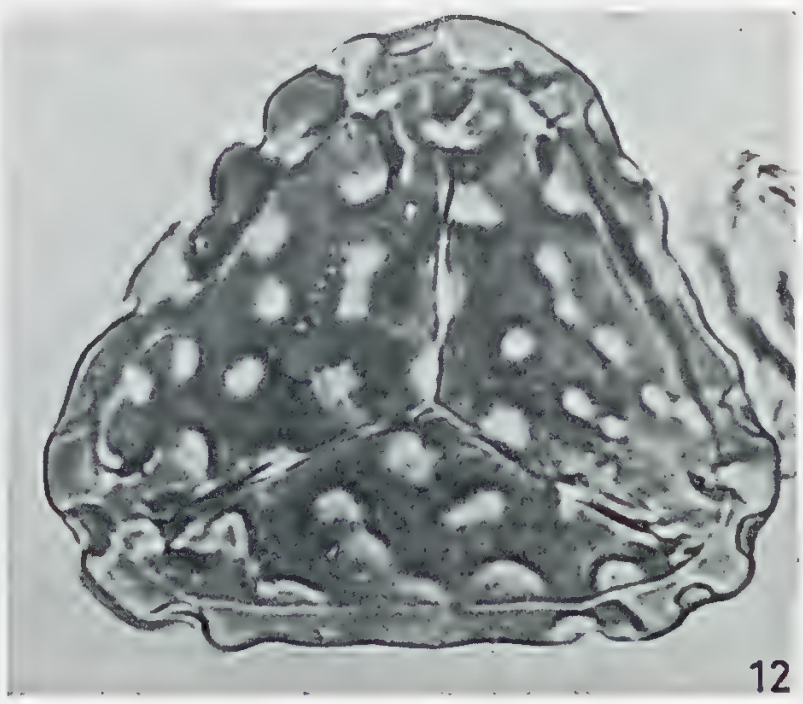
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PLATE 3

PLATE 4

(All photographs approximately ×1000)

Figure 1 —*Densosporites raceviewensis* sp. nov. (Holotype, proximal focus).

Figure 2 —*Densosporites raceviewensis* sp. nov. (Holotype, distal focus).

Figure 3 —*Polycingulatisporites densatus* (de Jersey) Playford and Dettmann, 1965 (median focus).

Figure 4 —*Densosporites raceviewensis* sp. nov. (proximal focus).

Figure 5 —*Polycingulatisporites crenulatus* Playford and Dettmann, 1965 (median focus).

Figure 6 —*Perinopollenites elatoides* Couper, 1958 (median focus, specimen with pore).

Figure 7 —*Nevesisporites vallatus* de Jersey and Paten, 1964 (proximal focus).

Figure 8 —*Polycingulatisporites mooniensis* de Jersey and Paten, 1964 (median focus).

Figure 9 —*Perinopollenites elatoides* Couper, 1958 (median focus).

Figure 10—*Zonalapollenites dampieri* Balme, 1957 (equatorial focus).

Figure 11—*Zonalapollenites segmentatus* Balme, 1957 (median focus).

Figure 12—*Aratrisporites* sp. cf. *A. minimus* Schulz, 1967 (median focus).

Figure 13—*Aratrisporites* sp. cf. *A. scabratus* Klaus, 1960 (median focus).

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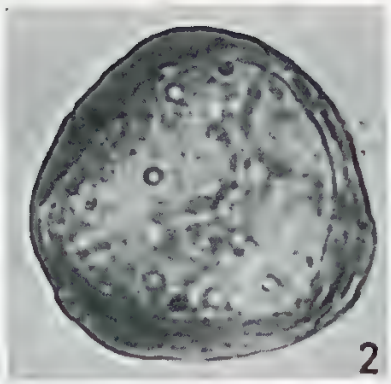
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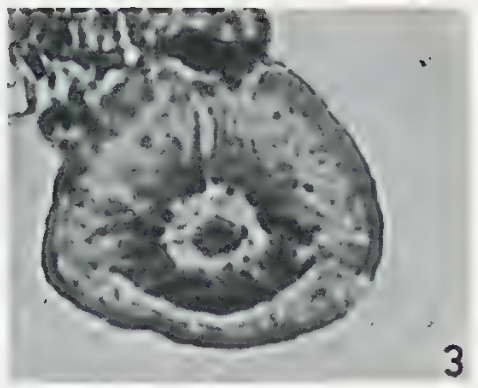
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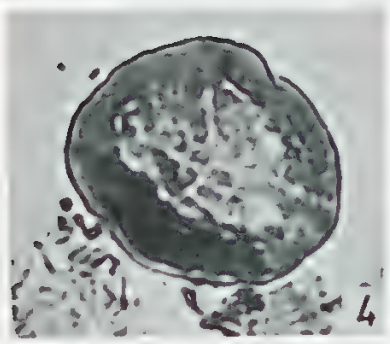
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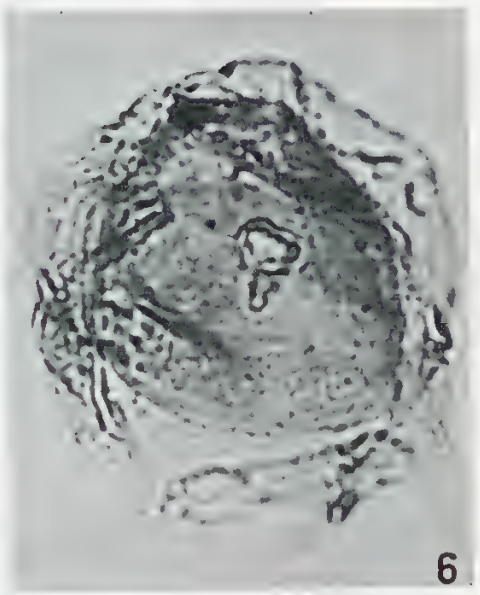
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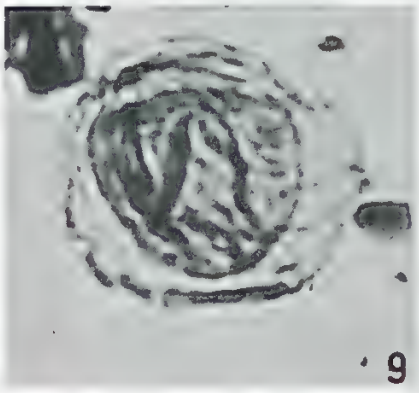
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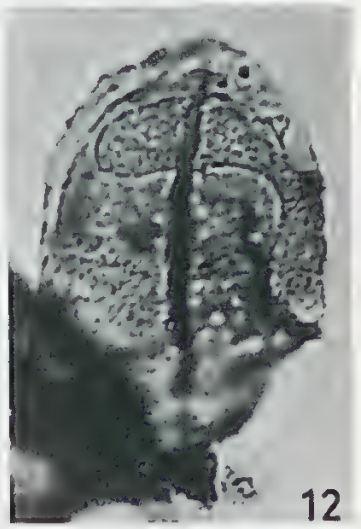
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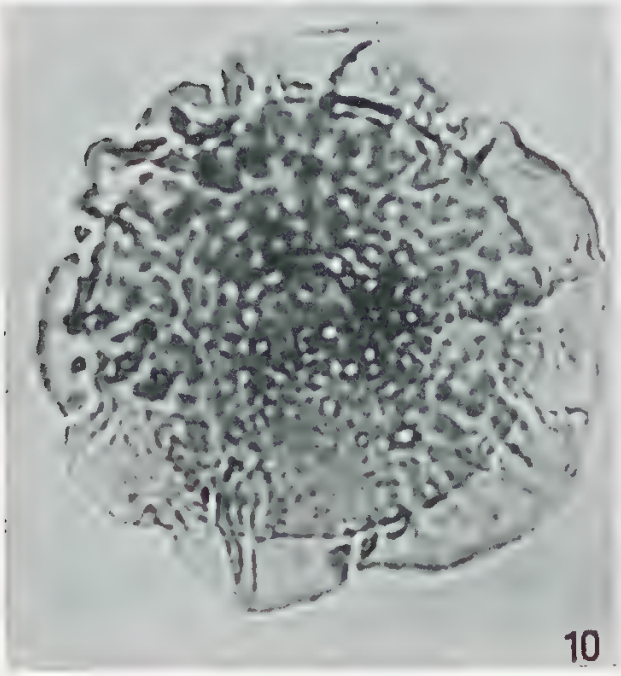
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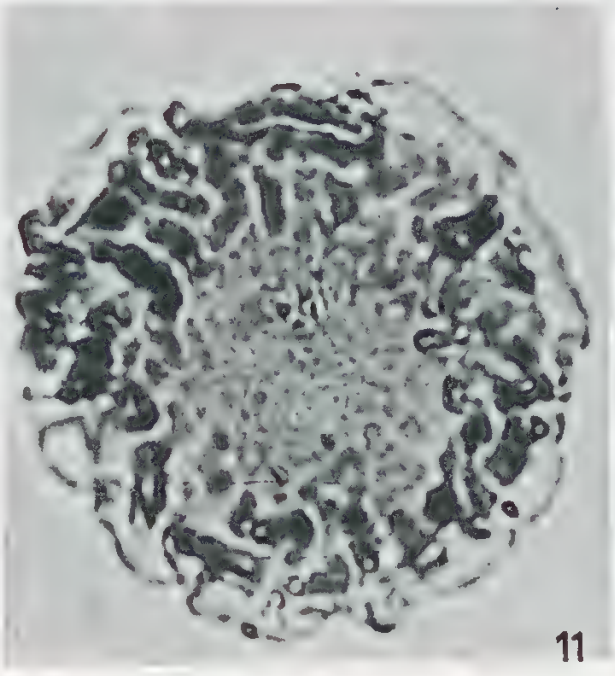
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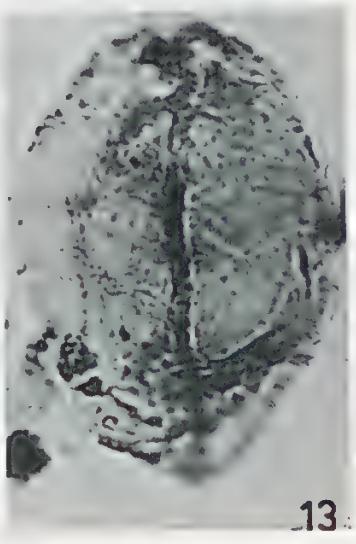
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PLATE 4

PLATE 5

(All photographs approximately ×1000)

Figure 1—*Trisaccites variabilis* (Dev) Haskell, 1968 (equatorial focus).

Figure 2—*Conaletes* sp. (median focus).

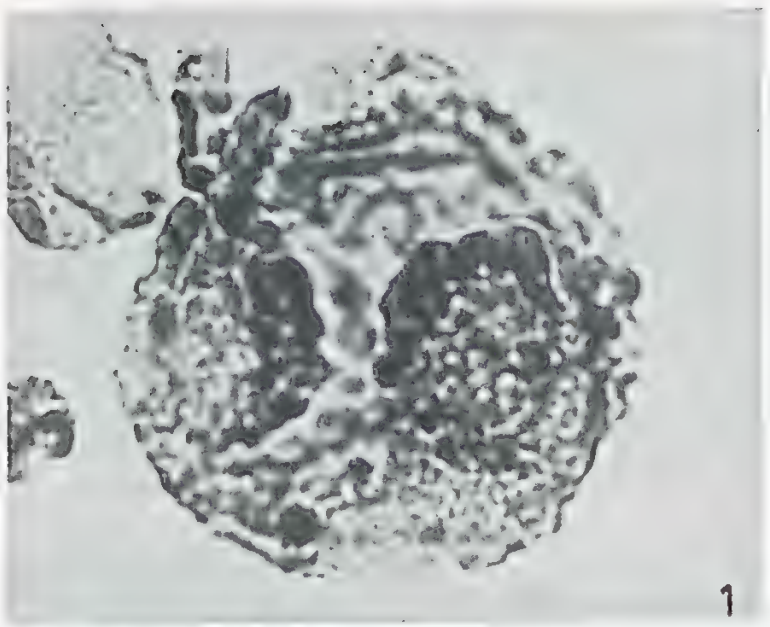
Figure 3—*Inaperturopollenites turbatus* Balme, 1957 (median focus).

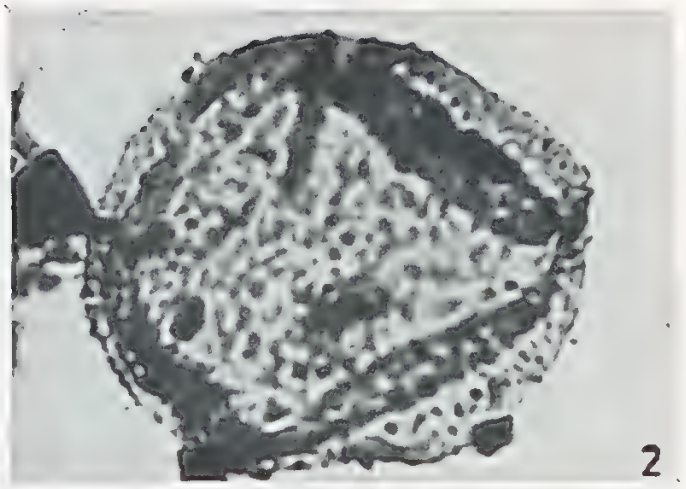
Figure 4—*Alisporites lowoodensis* de Jersey, 1963 (median focus).

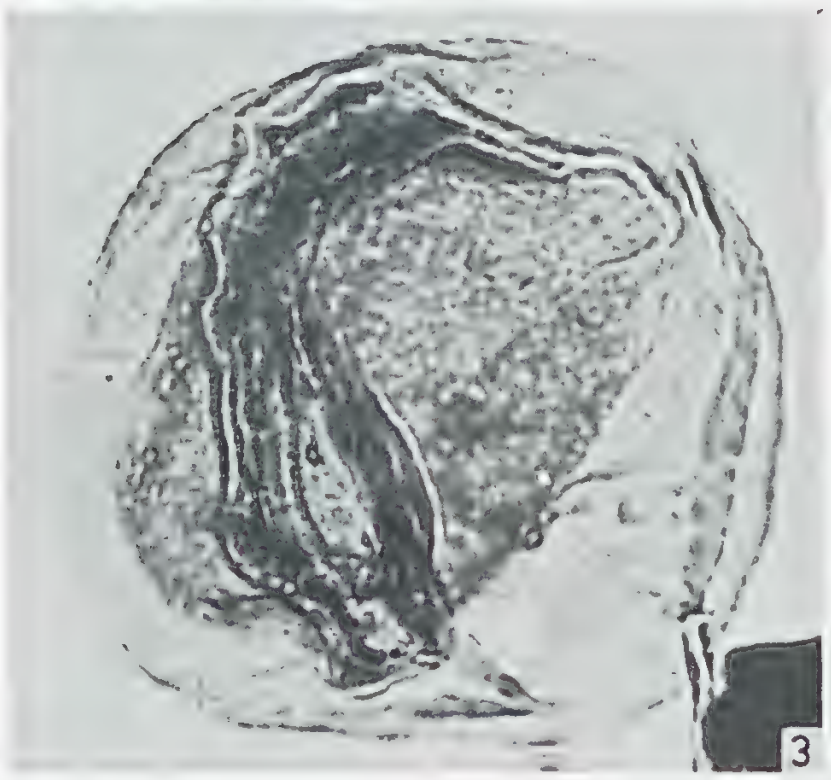
Figure 5—*Alisporites similis* (Balme) Dettmann, 1963 (distal focus).

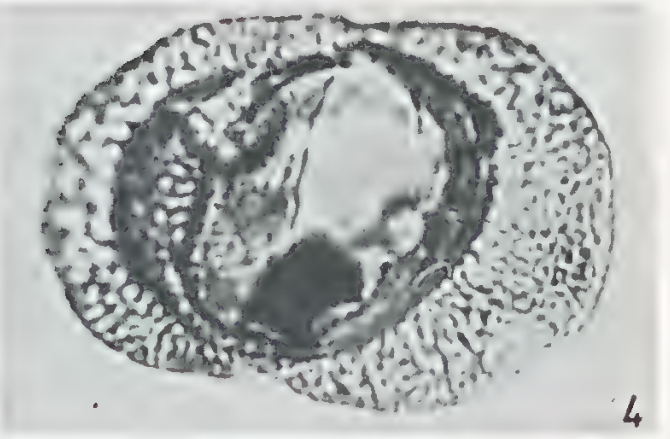
Figure 6—*Zonalapollenites dampieri* Balme, 1957 (equatorial focus, specimen with trilete mark).

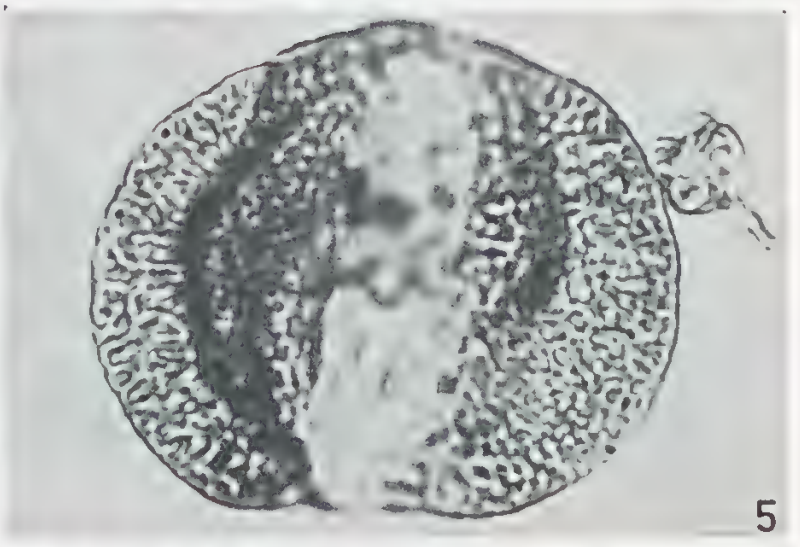
Figure 7—*Podocarpidites* sp. cf. *P. ellipticus* Cookson, 1947 (median focus).

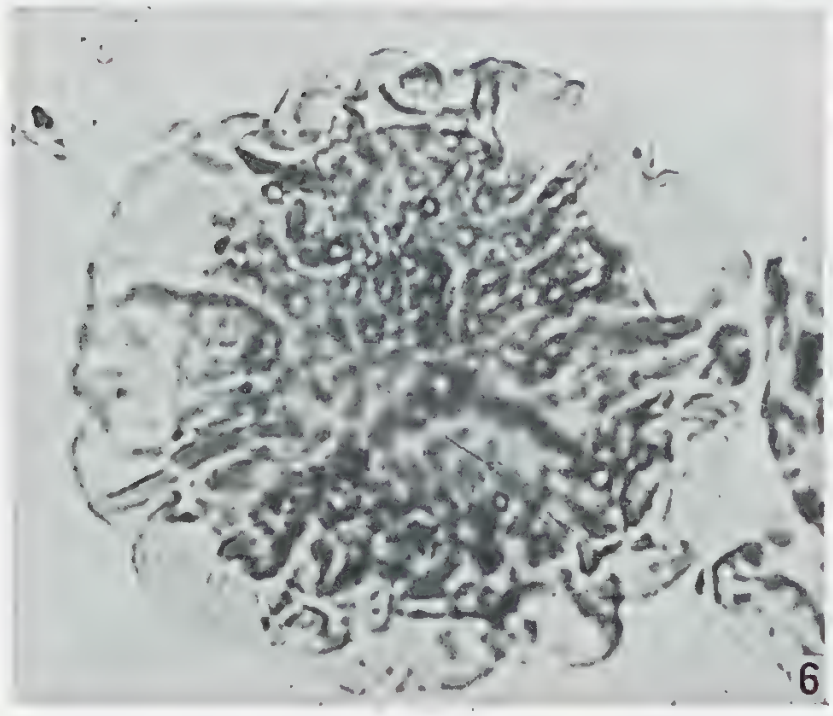












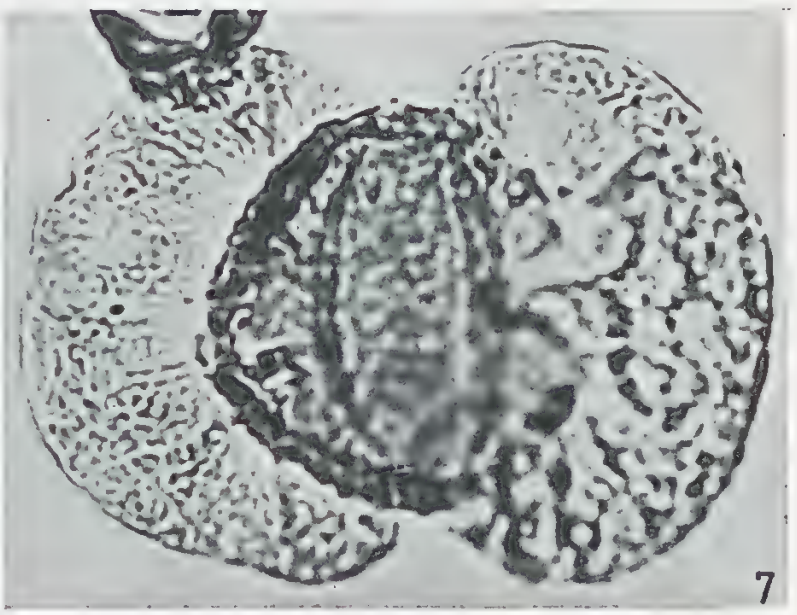


PLATE 5

PLATE 6

(All photographs approximately ×1000)

Figure 1 —*Classopollis classoides* Pflug *emend.* Pocock and Jansonius, 1961 (polar view, proximal focus).

Figure 2 —*Classopollis classoides* Pflug *emend.* Pocock and Jansonius, 1961 (equatorial view, focussed on well developed striations).

Figure 3 —*Classopollis classoides* Pflug *emend.* Pocock and Jansonius, 1961 (equatorial view, striations breaking up into discrete elements).

Figure 4 —*Classopollis simplex* (Danzé-Corsin and Laveine) Reiser and Williams, 1969 (equatorial view, showing thickened equatorial girdle with infragranulate sculpture).

Figure 5 —*Classopollis classoides* Pflug *emend.* Pocock and Jansonius, 1961 (equatorial view, specimen with shrunken intexine).

Figure 6 —*Gliscopollis meyeriana* (Klaus) Venkatachala, 1966 (polar view, proximal focus).

Figure 7 —*Gliscopollis meyeriana* (Klaus) Venkatachala, 1966 (polar view, distal focus, same specimen as Figure 6).

Figure 8 —*Classopollis simplex* (Danzé-Corsin and Laveine) Reiser and Williams, 1969 (polar view, proximal focus).

Figure 9 —*Equisetosporites* sp. cf. *E. tortuosus* (Mädler) comb. nov. (median focus).

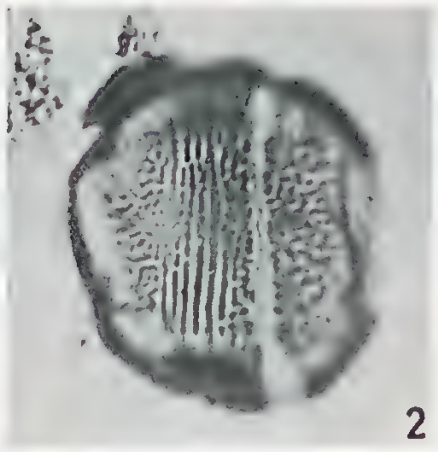
Figure 10—*Discisporites psilatus* de Jersey, 1964 (median focus).

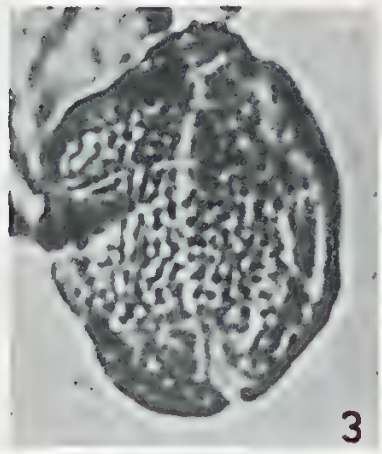
Figure 11—*Gliscopollis meyeriana* (Klaus) Venkatachala, 1966 (polar view, median focus).

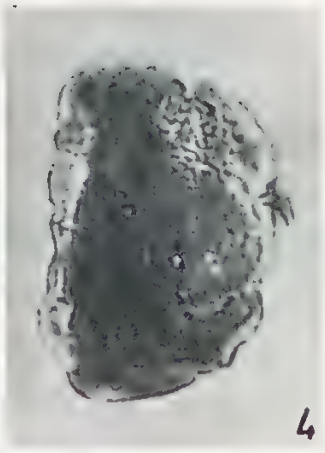
Figure 12—*Cerebropollenites* sp. cf. *C. thiergartii* Schulz, 1967 (median focus).

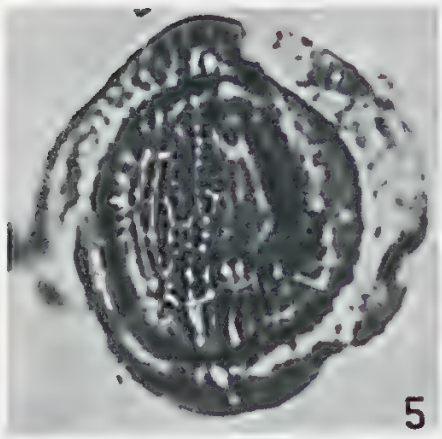
Figure 13—*Cerebropollenites* sp. cf. *C. macroverrucosus* (Thiergart) Schulz, 1967 (proximal focus).

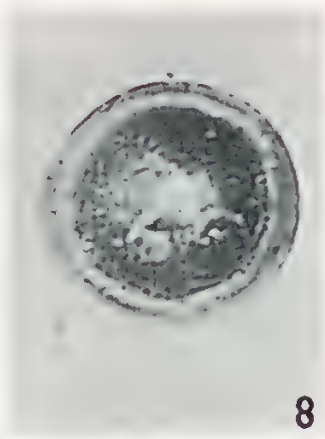
Figure 14—*Cerebropollenites* sp. cf. *C. macroverrucosus* (Thiergart) Schulz, 1967 (distal-equatorial focus, same specimen as Figure 13).

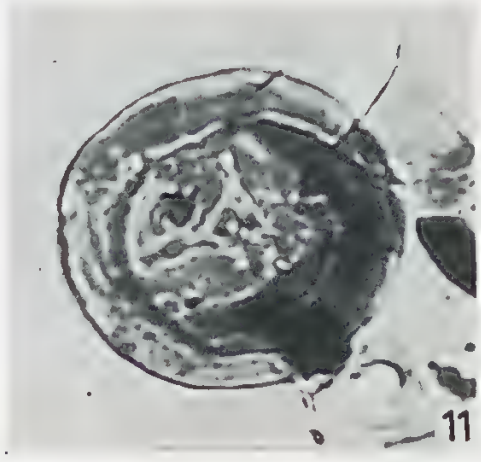


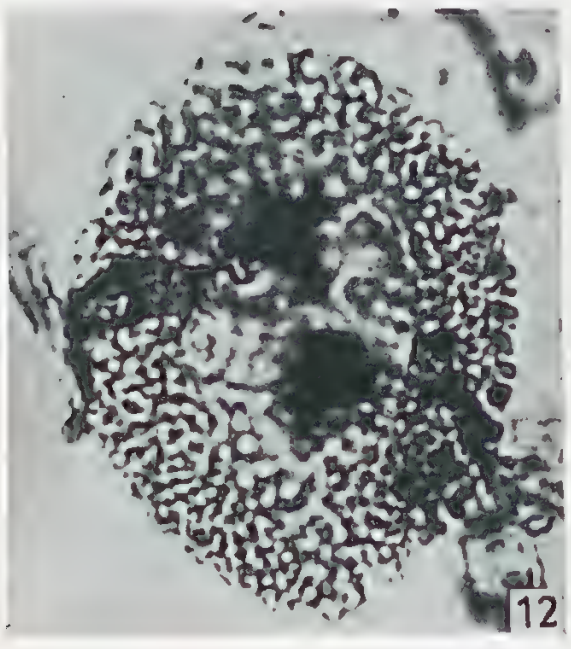


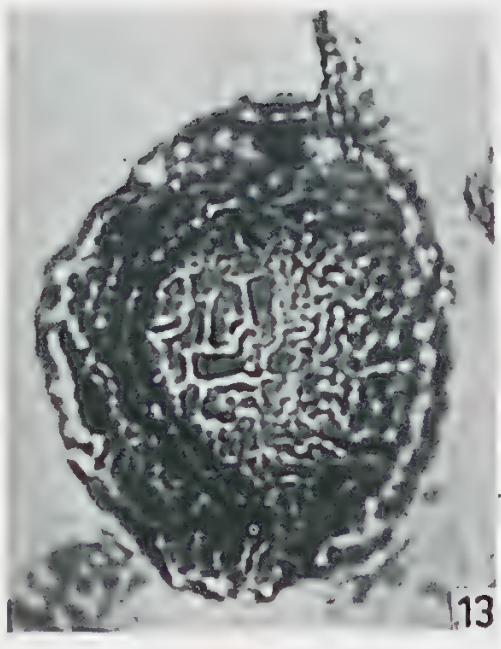












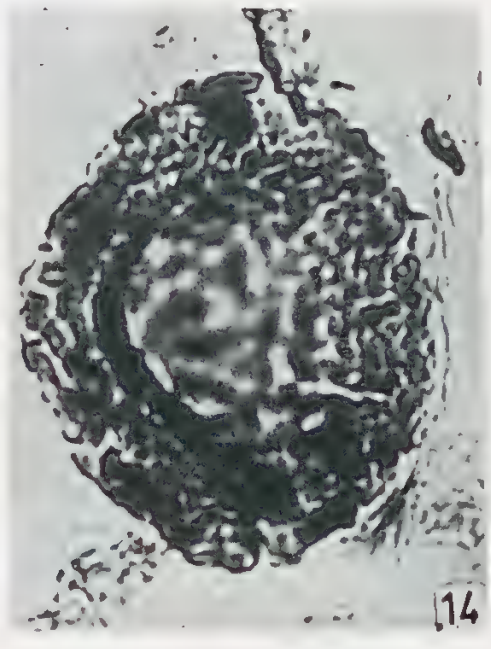


PLATE 6

APPENDIX — Lists of Microfloral Assemblages

The assemblages recorded below are arranged in ascending stratigraphic order for each of the boreholes studied. In the heading for each sample, depth, lithology, formation and number of specimens are recorded. Regarding the latter, the figures indicate that counts of these magnitudes were made; addition of the + sign, e.g. 200+, indicates that an additional low power traverse was made of the available slides. Species recorded only in such additional traverses are indicated by the sign + in each list. Indeterminate specimens have not been included.

G.S.Q. IPSWICH 1

RACEVIEW FORMATION

741ft., 1in.

Grey shale Count 200+

Anapiculatisporites dawsonensis	0.5%
Apiculatisporis spp.	1.0%
Araucariacites spp. (indet.)	2.5%
Camerosporites clarkei	+
Conaletes sp.	0.5%
Converrucosisporites cameroni	0.5%
Cycadopites nitidus	3.5%
Cycadopites sp. (indet.)	0.5%
Inaperturopollenites spp. (indet.)	5.5%
Leiotriletes directus	1.0%
Osmundacidites sp.	+
Polypodiisporites ipsviciensis	1.5%
Verrucosisporites sp.	1.0%
Vitreisporites pallidus	1.0%
Disaccites (indet.)	81.0%

RIPLEY ROAD SANDSTONE

483ft., 7in.

Dark grey shale Count 200+

Annulispora folliculosa	+
Annulispora microannulata	1.5%
Apiculatisporis spp.	1.0%
Araucariacites spp. (indet.)	2.5%
Cadargasporites reticulatus	+
Conaletes spp.	4.5%
Converrucosisporites cf. *cameroni*	0.5%
Cycadopites nitidus	1.0%
Dictyophyllidites mortoni	4.5%
Duplexisporites problematicus	0.5%
Foveosporites moretonensis	0.5%
Granulatisporites spp.	3.0%
Inaperturopollenites spp. (indet.)	4.0%
cf. *Indospora* sp.	0.5%
Leiotriletes directus	12.5%
Lophotriletes sp.	0.5%
Lycopodiumsporites rosewoodensis	1.5%
Osmundacidites spp.	18.5%
Perinopollenites elatoides	2.5%
Polycingulatisporites crenulatus	0.5%
Polycingulatisporites densatus	2.0%
Polycingulatisporites mooniensis	2.5%
Polycingulatisporites cf. *mooniensis*	0.5%
Stereisporites antiquasporites	0.5%
Stereisporites perforatus	+
Stereisporites sp. (indet.)	8.0%
Vitreisporites pallidus	+
Zebrasporites interscriptus	+
Disaccites (indet.)	27.5%

384ft., 6in.

Grey shale Count 200+

Annulispora microannulata	+
Apiculatisporis spp.	2.0%
Araucariacites spp. (indet.)	1.0%
Cadargasporites reticulatus	0.5%
Ceratosporites helidonensis	+
Conaletes spp.	3.5%
Converrucosisporites cameroni	+
Converrucosisporites sp. (indet.)	0.5%
Cycadopites nitidus	4.0%
Dictyophyllidites mortoni	2.0%
Discisporites psilatus	+
Duplexisporites problematicus	+
Foveosporites moretonensis	+
Gliscopollis meyeriana	+
Granulatisporites spp.	1.5%
Inaperturopollenites spp. (indet.)	4.5%
Leiotriletes directus	6.5%
Lophotriletes sp.	+
Lycopodiumsporites rosewoodensis	0.5%
Osmundacidites spp.	5.0%
Perinopollenites elatoides	3.5%
Platysaccus queenslandi	0.5%
Polycingulatisporites crenulatus	+
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	1.5%
Disaccites (indet.)	62.0%
Parasaccites sp. (reworked)	+
Acritarch: *Veryhachium* sp. (? reworked)	0.5%

192ft., 1in.

Grey shale Count 200+

Anapiculatisporites dawsonensis	+
Annulispora microannulata	0.5%
Apiculatisporis spp.	2.5%
Araucariacites spp. (indet.)	5.5%
Baculatisporites comaumensis	0.5%
Cadargasporites reticulatus	1.0%
Ceratosporites helidonensis	0.5%
Classopollis classoides	9.5%
Conaletes spp.	16.5%
Conbaculatisporites sp.	0.5%
Converrucosisporites sp.	0.5%
Cyathidites sp. (indet.)	0.5%
Dictyophyllidites mortoni	0.5%
Discisporites psilatus	0.5%
Duplexisporites problematicus	0.5%
Foveosporites moretonensis	0.5%
Foveosporites sp. (indet.)	1.0%
Gliscopollis meyeriana	3.5%
Granulatisporites spp.	2.0%
Inaperturopollenites spp. (indet.)	2.0%
Leiotriletes directus	7.0%
Lophotriletes sp.	0.5%
Lycopodiumsporites austroclavatidites	1.5%
Lycopodiumsporites rosewoodensis	1.0+
Lycopodiumsporites semimuris	+
Osmundacidites spp.	9.0%
Perinopollenites elatoides	8.0%
Polycingulatisporites crenulatus	0.5%
Polycingulatisporites mooniensis	0.5%
Rugulatisporites sp.	6.5%
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	0.5%
Vitreisporites pallidus	1.5%
Disaccites (indet.)	20.5%
cf. *Indospora* sp. (? reworked)	+
Parasaccites sp. (reworked)	+

N.S. 272 (IPSWICH)

RIPLEY ROAD SANDSTONE

1128ft., 9in.

Grey shale Count 200+

Apiculatisporis globosus	+
Cadargasporites reticulatus	+
Cycadopites nitidus	5.0%
Cycadopites cf. *potoniei*	+
Cycadopites sp. (indet.)	1.0%
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	+
Foveosporites sp.	0.5%
Inapertuorpollenites spp. (indet.)	6.5%
Leiotriletes directus	1.0%
Polypodiisporites ipsviciensis	7.5%
Stereisporites sp. (indet.)	1.0%
Disaccites (indet.)	77.0%

603ft., 4in.

Grey siltstone Count 200+

Anapiculatisporites dawsonensis	+
Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Apiculatisporis spp.	1.0%
Aratrisporites cf. *minimus*	+
Araucariacites spp. (indet.)	1.0%
Baculatisporites sp. (indet.)	0.5%
Cadargasporites baculatus	+
Cadargasporites reticulatus	+
Camerosporites clarkei	+
Ceratosporites helidonensis	+
Conaletes spp.	4.0%
Conbaculatisporites sp. A	+
Cycadopites nitidus	2.5%
Cycadopites sp. (indet.)	+
cf. *Densoisporites* sp.	+
Dictyophyllidites cf. *harrisii*	0.5%
Dictyophyllidites mortoni	0.5%
Dictyophyllidites sp. (indet.)	0.5%
Discisporites psilatus	+
Duplexisporites problematicus	1.0%
Equisetosporites cf. *tortuosus*	0.5%
Foveosporites moretonensis	+
Foveosporites sp. (indet.)	0.5%
Gliscopollis meyeriana	+
Granulatisporites sp.	0.5%
Inaperturopollenites spp. (indet.)	14.0%
Indusiisporites parvisaccatus	0.5%
Laevigatosporites sp.	0.5%
Leiotriletes directus	6.5%
Lycopodiacidites cf. *kuepperi*	+
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites cf. *semimuris*	+
Osmundacidites spp.	1.5%
Perinopollenites elatoides	14.5%
Polycingulatisporites crenulatus	0.5+
Polycingulatisporites densatus	+
Polycingulatisporites mooniensis	+
Polypodiisporites ipsviciensis	+
Punctatosporites walkomi	1.0%
Stereisporites antiquasporites	+
Stereisporites perforatus	+
Stereisporites sp. (indet.)	6.0%
Verrucosisporites sp.	0.5%
Vitreisporites pallidus	1.0%
Disaccites (indet.)	40.5%

G.S.Q. IPSWICH 4

RACEVIEW FORMATION

1125ft., 1in.

Dark grey carb. shale Count 200+

Apiculatisporis globosus	+
Baculatisporites comaumensis	+
Camerosporites clarkei	+
Chordasporites sp.	0.5%
Converrucosisporites cf. *cameroni*	+
Cycadopites nitidus	0.5%
cf. *Cycadopites* sp.	+
Dictyophyllidites mortoni	+
Discisporites psilatus	+
Duplexisporites problematicus	0.5%
cf. *Foveosporites* sp.	+
Inaperturopollenites spp. (indet.)	1.0%
Lophotriletes sp.	+
Osmundacidites spp.	1.0%
Platysaccus queenslandi	1.0%
Polycingulatisporites crenulatus	+
Polypodiisporites ipsviciensis	0.5%
Stereisporites sp.	+
Vitreisporites microsaccus	+
Disaccites (indet.)	95.0%

1042ft., 3in

Dark grey shale Count 200+

Alisporites lowoodensis	+
Annulispora microannulata	+
cf. *Annulispora* sp.	0.5%
Apiculatisporis globosus	0.5%
Apiculatisporis sp. (indet.)	1 5%
Araucariacites spp. (indet.)	1.5%
Baculatisporites comaumensis	0.5%
Baculatisporites sp. (indet.)	+
Cqmerosporites clarkei	5.5%
Conaletes sp.	3.0%
Craterisporites rotundus	0.5%
Cycadopites nitidus	0.5%
Densosporites raceviewensis	5.5%
Dictyophyllidites mortoni	2.0%
Duplexisporites problematicus	0.5%
Duplicisporites sp. A	+
Foveosporites moretonensis	0.5%
Foveosporites sp. (indet.)	1.5+
cf. *Foveosporites* sp.	+
Gliscopollis meyeriana	0.5%
Inaperturopollenites fuscus	0.5%
Inaperturopollenites spp. (indet.)	2.5%
Indusiisporites sp.	+
Leiotriletes directus	3.5%
Osmundacidites spp.	4.0%
Polycingulatisporites crenulatus	+
Polypodiisporites ipsviciensis	1.0%
Semiretisporis antiquus	5.5%
Stereisporites cf. *antiquasporites*	+
Stereisporites sp. (indet.)	1.0%
Verrucosisporites spp.	1.0%
Vitreisporites microsaccus	0.5%
Disaccites (indet.)	56.0%
Nevesisporites limatulus (? reworked)	+
Striate bisaccate pollen (? reworked)	+

1015ft., 9in.

Black mudstone Count 200+

Alisporites lowoodensis	+
cf. *Annulispora* sp.	2.0%
Apiculatisporis globosus	0.5%
Apiculatisporis sp. (indet.)	2.5%
Araucariacites spp. (indet.)	5.5%
Camerosporites clarkei	1.0%
Conaletes spp.	5.0%
Converrucosisporites cameroni	1.0%
Cycadopites granulatus	0.5%
Cycadopites nitidus	1.0%
Densosporites raceviewensis	+

Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	+
Foveosporites spp.	1.5%
Granulatisporites sp.	0.5%
Leiotriletes directus	4.5%
Lophotriletes sp.	0.5%
Lycopodiumsporites rosewoodensis	1.0%
Osmundacidites cf. *parvus*	0.5%
Osmundacidites spp. (indet.)	15.0%
Polycingulatisporites crenulatus	+
Polycingulatisporites densatus	1.5%
Polypodiisporites ipsviciensis	33.5%
Semiretisporis antiquus	0.5%
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	1.5%
Verrucosisporites spp.	2.0%
Vitreisporites cf. *microsaccus*	0.5%
Disaccites (indet.)	17.0%

993ft., 4in.

Dark grey carb. mudstone Count 200+

Anapiculatisporites cf. *pristidentatus*	+
Annulispora folliculosa	+
Apiculatisporis globosus	2.0%
Apiculatisporis spp. (indet.)	6.0%
Araucariacites sp. (indet.)	0.5%
Baculatisporites comaumensis	1.0%
Camerosporites clarkei	1.0%
Converrucosisporites cameroni	0.5%
Converrucosisporites sp. (indet.)	0.5%
Cycadopites magnus	+
Cycadopites cf. *potoniei*	+
aff. *Cycadopites* sp.	0.5%
Densosporites raceviewensis	+
Dictyophyllidites mortoni	0.5%
Discisporites psilatus	+
Duplexisporites problematicus	+
Duplicisporites sp.	0.5%
Gliscopollis meyeriana	0.5%
Inaperturopollenites spp. (indet.)	4.5%
Indusiisporites sp.	0.5%
Leiotriletes directus	0.5%
Osmundacidites spp.	7.5%
Perinopollenites sp.	+
Platysaccus queenslandi	+
Polycingulatisporites densatus	+
Polycingulatisporites mooniensis	+
Polypodiisporites ipsviciensis	12.0%
Semiretisporis antiquus	+
Verrucosisporites sp.	0.5%
Vitreisporites cf. *microsaccus*	0.5%
Disaccites (indet.)	60.5%

HELIDON SANDSTONE

745ft., 5in.

Grey mudstone Count 200+

Anapiculatisporites sp.	+
Annulispora folliculosa	+
cf. *Annulispora* sp.	0.5%
Apiculatisporis spp.	2.5%
Arancariacites spp. (indet.)	8.0%
Cadargasporites reticulatus	0.5%
Ceratosporites helidonensis	0.5%
Classopollis classoides	31.5%
Classopollis simplex	+
Classopollis sp.	0.5%
Conaletes spp.	8.5%
Converrucosisporites sp.	0.5%
Cycadopites nitidus	0.5%
Dictyophyllidites mortoni	1.0%
Duplexisporites problematicus	1.0%
Gliscopollis meyeriana	1.0%
Inaperturopollenites spp. (indet.)	5.0%
Leiotriletes directus	1.5%
Lophotriletes sp.	+
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites cf. *semimuris*	+
Lycopodiumsporites sp. (indet.)	1.0%
Osmundacidites spp.	14.0%
Perinopollenites elatoides	10.0%
Polycingulatisporites mooniensis	+
Verrucosisporites spp.	1.0%
Vitreisporites pallidus	0.5%
Disaccites (indet.)	9.5%

639ft., 11in.

Grey siltstone Count 200+

Alisporites lowoodensis	0.5%
Annulispora folliculosa	+
Apiculatisporis globosus	+
Apiculatisporis spp. (indet.)	1.5%
Aratrisporites cf. *banksi*	+
Araucariacites spp. (indet.)	3.0%
Baculatisporites comaumensis	0.5%
Baculatisprites sp. (indet.)	0.5%
Cadargasporites baculatus	+
Cadargasporites granulatus	+
Cadargasporites reticulatus	+
Camarzonosporites rudis	+
Ceratosporites helidonensis	2.0%
Classopollis classoides	16.0%
Classopollis simplex	0.5%
Conaletes spp.	8.5%
Cycadopites nitidus	0.5%
cf. *Densosporites* sp.	+
Dictyophyllidites mortoni	+
Duplexisporites problematicus	0.5%
Foraminisporis tribulosus	+
Foveosporites moretonensis	+
Gliscopollis meyeriana	1.0%
Inaperturopollenites spp. (indet.)	8.0%
Indusiisporites parvisaccatus	+
Leiotriletes directus	3.0%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	1.0%
Osmundacidites wellmanii	0.5%
Osmundacidites spp. (indet.)	12.0%
Perinopollenites elatoides	10.5%
Pilosisporites sp.	+
Polycingulatisporites crenulatus	+
Polycingulatisporites mooniensis	+
Stereisporites antiquasporites	+
Stereisporites spp. (indet.)	2.5%
Vitreisporites pallidus	7.0%
Disaccites (indet.)	20.5%

603ft., 9in.

Grey mudstone Count 200+

Alisporites lowoodensis	2.5%
Alisporites similis	6.5%
Anapiculatisporites dawsonensis	+
Anapiculatisporites sp. (indet.)	+
Annulispora folliculosa	0.5%
Annulispora microannulata	0.5%
Antulsporites varigranulatus	0.5%
Araucariacites fissus	0.5%
Araucariacites spp. (indet.)	4.0%
Baculatisporites comaumensis	1.0%
Baculatisporites sp. (indet.)	+
Ceratosporites helidonensis	+
Classopollis classoides	28.5%

Classopollis simplex	+
Conaletes spp.	5.5%
Cycadopites nitidus	2.5%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	0.5%
Foveosporites sp.	+
Gliscopollis meyeriana	0.5%
Granulatisporites sp.	0.5%
Inaperturopollenites spp. (indet.)	4.0%
Indusiisporites parvisaccatus	0.5%
Leiotriletes directus	3.0%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites semimuris	+
Osmundacidites spp.	11.5%
Perinopollenites elatoides	3.5%
Polycingulatisporites mooniensis	0.5%
Punctatosporites walkomi	0.5%
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	1.5%
Vitreisporites pallidus	4.5%
Disaccites (indet.)	20.5%

435ft., 5in.

Light grey siltstone Count 200+

Alisporites lowoodensis	+
Anapiculatisporites pristidentatus	+
cf. *Annulispora* sp.	+
Antulsporites varigranulatus	+
Apiculatisporis globosus	+
Araucariacites fissus	+
Araucariacites spp. (indet.)	1.5%
Baculatisporites comaumensis	0.5%
Cadargasporites reticulatus	+
Camarozonosporites rudis	+
Ceratosporites helidonensis	+
Classopollis classoides	41.0%
Classopollis simplex	+
Conaletes spp.	2.5%
Cycadopites nitidus	1.0%
Foveosporites spp.	1.5%
Gliscopollis meyeriana	6.5%
Granulatisporites sp.	1.0%
Inaperturopollenites spp. (indet.)	6.5%
Leiotriletes directus	8.0%
Lycopodiumsporites austroclavatidites	1.5%
Lycopodiumsporites rosewoodensis	3.0%
Lycopodiumsporites semimuris	0.5%
Osmundacidites cf. *fissus*	0.5%
Osmundacidites wellmanii	1.0%
Osmundacidites spp. (indet.)	15.0%
Perinopollenites elatoides	4.0%
Polycingulatisporites crenulatus	+
Polycingulatisporites densatus	+
Polycingulatisporites mooniensis	+
Stereisporites spp.	1.0%
Vitreisporites pallidus	4.5%
Vitreisporites sp. (indet.)	0.5%
Disaccites (indet.)	4.5%
Parasaccites sp. (reworked)	+

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HELIDON SANDSTONE

1189ft.

Grey siltstone Count 200+

Alisporites lowoodensis	0.5%
Alisporites cf. *similis*	1.0%
Anapiculatisporites dawsonensis	0.5%
Annulispora folliculosa	+
Apiculatispora cf. *globosus*	+
Cadargasporites reticulatus	+
Ceratosporites helidonensis	1.0%
Classopollis classoides	46.0%
Classopollis simplex	+
Conaletes spp.	1.0%
Dictyophyllidites harrisii	+
Dictyophyllidites mortoni	0.5%
Discisporites sp.	+
Duplexisporites problematicus	0.5%
Gliscopollis meyeriana	+
Inaperturopollenites spp. (indet.)	3.5%
Indusiisporites parvisaccatus	+
Leiotriletes directus	0.5%
Neoraistrickia cf. *taylorii*	+
Osmundacidites spp.	2.0%
Perinopollenites elatoides	1 5%
Platysaccus queenslandi	+
Podocarpidites sp.	+
Polycingulatisporites crenulatus	+
Polycingulatisporites mooniensis	+
Stereisporites antiquasporites	+
Stereisporites sp. (indet.)	1.5%
Verrucosisporites sp.	+
Vitreisporites pallidus	0.5%
Disaccites (indet.)	39.5%
Parasaccites sp. (reworked)	+

1154ft., 11in.

Grey siltstone Count 200+

Acanthotriletes sp. (indet.)	0.5%
Alisporites lowoodensis	0.5%
Anapiculatisporites dawsonensis	1.5%
Apiculatisporis sp. (indet.)	0.5%
Araucariacites spp. (indet.)	1.0%
Cadargasporites reticulatus	0.5%
Ceratosporites helidonensis	+
Classopollis classoides	52.0%
Classopollis simplex	+
Conaletes spp.	1.5%
Cycadopites nitidus	0.5%
Duplexisporites problematicus	0.5%
Foveosporites moretonensis	+
Gliscopollis meyeriana	2.0%
Inaperturopollenites spp. (indet.)	4.0%
Leiotriletes directus	8.5%
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites cf. *semimuris*	+
Osmundacidites spp.	5.0%
Perinopollenites elatoides	5.0%
Stereisporites cf. *antiquasporites*	0.5%
Disaccites (indet.)	14.5%

1046ft., 10in.

Grey siltstone Count 200+

Anapiculatisporites dawsonensis	
Apiculatisporis spp.	1.5%
Araucariacites spp. (indet.)	1.0%
Baculatisporites sp.	+
Cadargasporites reticulatus	0.5%
Ceratosporites helidonensis	+
Classopollis classoides	43.5%
Classopollis simplex	+
Conaletes sp.	0.5%
Dictyophyllidites mortoni	+
Foveosporites sp.	0.5%
Gliscopollis meyeriana	0.5%
Granulatisporites sp.	0.5%
Inaperturopollenites spp. (indet.)	1.5%
Leiotriletes directus	1.5%
Lophotriletes sp.	0.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites cf. *semimuris*	0.5%
Osmundacidites spp.	2.0%
Perinopollenites elatoides	8.0%

Podocarpidites sp.	+
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	0.5%
Vitreisporites pallidus	3.0%
Disaccites (indet.)	33.5%
Granulatisporites micronodosus (reworked)	+

825ft., 2in.

Grey mudstone Count 200+

Alisporites lowoodensis	+
Anapiculatisporites dawsonensis	+
Annulispora folliculosa	+
Baculatisporites comaumensis	+
Cadargasporites baculatus	+
Cadargasporites reticulatus	+
Ceratosporites helidonensis	+
Classopollis classoides	52.0%
Classopollis simplex	+
Conbaculatisporites sp. A	1.0%
Cyathidites sp.	0.5%
Cycadopites nitidus	0.5%
Dictyophyllidites mortoni	+
Duplexisporites problematicus	+
Foveosporites moretonensis	+
Gleicheniidites cf. *senonicus*	+
Gliscopollis meyeriana	+
Granulatisporites spp.	1.5%
Inaperturopollenites spp. (indet.)	2.5%
Indusiisporites parvisaccatus	+
Leiotriletes directus	2.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	+
Osmundacidites spp.	0.5%
Perinopollenites elatoides	4.0%
Platysaccus queenslandi	+
Polycingulatisporites mooniensis	+
Stereisporites antiquasporites	+
Stereisporites perforatus	+
Stereisporites sp. (indet.)	0.5%
Vitreisporites pallidus	7.5%
Disaccites (indet.)	27.0%

730ft., 1in.

Grey siltstone Count 200+

Alisporites lowoodensis	+
Anapiculatisporites dawsonensis	+
Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Annulispora microannulata	+
Apiculatisporis sp. (indet.)	0.5%
Arancariacites spp. (indet.)	1.0%
Baculatisporites comaumensis	+
Cadargasporites baculatus	+
Cadargasporites reticulatus	+
Camerosporites clarkei	0.5%
Cingutriletes cf. *clavus*	+
Classopollis classoides	63.0%
Classopollis simplex	0.5%
Conaletes spp.	1.0%
Converrucosisporites sp.	0.5%
Cycadopites nitidus	0.5%
Duplexisporites problematicus	+
Foveosporites moretonensis	+
Granulatisporites sp.	0.5%
Inaperturopollenites spp. (indet.)	3.0%
Indusiisporites parvisaccatus	+
Indusiisporites sp. (indet.)	0.5%
Leiotriletes directus	3.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	0.5%
Osmundacidites spp.	2.0%
Perinopollenites elatoides	10.0%
Pérotriletes sp.	+
Polycingulatisporites densatus	+
Polycingulatisporites mooniensis	+
Stereisporites perforatus	+
Stereisporites sp. (indet.)	0.5%
Taurocusporites sp.	+
Vitreisporites pallidus	2.5%
Disaccites (indet.)	9.5%
Parasacites sp. (reworked)	+

575ft., 10in.

Grey mudstone Count 200+

Alisporites similis	+
Annulispora microannulata	+
Antulsporites varigranulatus	+
Apiculatisporis sp.	6.5%
Araucariacites fissus	0.5%
Araucariacites spp. (indet.)	4.0%
Baculatisporites sp.	+
Cadargasporites baculatus	0.5%
Cadargasporites reticulatus	0.5%
Cerebropollenites cf. *macroverrucosus*	+
cf. *Cerebropollenites* sp.	+
Cingutriletes cf. *clavus*	+
Conaletes sp.	+
Classopollis classoides	5.5%
Classopollis simplex	0.5%
Foveosporites spp.	1.0%
Granulatisporites spp.	1.5%
Inaperturopollenites spp. (indet.)	4.5%
Leiotriletes directus	0.5%
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites semimuris	+
Lycopodiumsporites sp. (indet.)	0.5%
Neoraistrickia sp.	0.5%
Nevesisporites vallatus	+
Osmundacidites spp.	13.0%
Perinopollenites elatoides	21.5%
Podocarpidites sp.	+
Polycingulatisporites mooniensis	+
Stereisporites perforatus	+
Stereisporites sp. (indet.)	1.5%
Vitreisporites pallidus	36.5%
Disaccites (indet.)	6.0%

531ft., 1in.

Grey Siltstone Count 200+

Acanthotriletes cf. *pallidus*	+
Anapiculatisporites dawsonensis	0.5%
Anapiculatisporites pristidentatus	+
Annulispora folliculosa	0.5%
Annulispora microannulata	+
cf. *Annulispora* sp.	+
Antulsporites varigranulatus	+
Apiculatisporis spp.	0.3%
Araucariacites fissus	0.5%
Araucariacites spp. (indet.)	2.5%
Cadargasporites baculatus	0.5%
Cadargasporites reticulatus	0.5%
Camarozonosporites rudis	+
Conaletes sp.	1.5%
Conbaculatisporites sp.	0.5%
Classopollis classoides	41.5%
Classopollis simplex	1.0%
Cycadopites nitidus	+
Dictyophyllidites mortoni	+
Foveosporites moretonensis	+
Gliscopollis meyeriana	1.0%
Inaperturopollenites spp. (indet.)	5.5%
Indusiisporites parvisaccatus	0.5%
Ischyosporites marburgensis	+
Leiotriletes directus	1.5%
Lophotriletes sp.	0.5%
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites semimuris	+

Neoraistrickia taylorii	+
Neoraistrickia sp. (indet.)	0.5%
Nevesisporites cf. *vallatus*	+
Osmundacidites wellmanii	0.5%
Osmundacidites sp. (indet.)	1.0%
Perinopollenites elatoides	15.5%
Podocarpidites sp.	+
Polycingulatisporites crenulatus	+
Polycingulatisporites densatus	+
Stereisporites antiquasporites	0.5%
Stereisporites perforatus	1.0%
Stereisporites sp. (indet.)	2.0%
Trisaccites variabilis	+
Vitreisporites pallidus	2.0%
Disaccites (indet.)	17.5%
Parasaccites sp. (reworked)	+

MARBURG FORMATION

153ft., 3in.

Grey siltstone Count 200+

Alisporites lowoodensis	0.5%
Alisporites similis	0.5%
Anapiculatisporites pristidentatus	+
Annulispora microannulata	+
Araucariacites fissus	+
Araucariacites spp. (indet.)	2.0%
Baculatisporites spp.	0.5%
Cadargasporites baculatus	+
Cadargasporites sp. (indet.)	1.0%
Classopollis classoides	37.5%
Conaletes sp.	0.5%
Cycadopites nitidus	0.5%
Gliscopollis meyeriana	0.5%
Inaperturopollenites spp. (indet.)	13.0%
Leiotriletes directus	2.0%
Osmundacidites spp.	1.5%
Perinopollenites elatoides	10.0%
Podocarpidites sp.	+
Stereisporites sp.	0.5%
Trisaccites variabilis	+
Vitreisporites pallidus	6.0%
Disaccites (indet.)	23.0%

130ft., 9in.

Grey carb. mudstone Count 200+

Anapiculatisporites dawsonensis	+
Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Annulispora microannulata	+
Antulsporites varigranulatus	+
Apiculatisporis taroomensis	+
Apiculatisporis sp. (indet.)	0.5%
Araucariacites fissus	0.5%
Araucariacites spp. (indet.)	1.5%
Cadargasporites baculatus	0.5%
Cadargasporites granulatus	+
Cadargasporites reticulatus	0.5%
Cadargasporites verrucosus	+
Camarozonosporites rudis	+
Classopollis classoides	36.0%
Conaletes spp.	1.5%
cf. *Cycadopites* sp.	0.5%
Duplexisporites problematicus	+
Inaperturopollenites spp. (indet.)	8.0%
Indusiisporites parvisaccatus	+
Leiotriletes directus	1.5%
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites semimuris	+
Neoraistrickia elongata	+
Neoraistrickia sp. (indet.)	0.5%
Nevesisporites vallatus	+
Osmundacidites spp.	5.0%
Perinopollenites elatoides	31.5%
Polycingulatisporites mooniensis	+
cf. *Raistrickia* sp.	+
Stereisporites perforatus	+
Stereisporites sp. (indet.)	1.0%
Trisaccites variabilis	+
Verrucosisporites sp.	0.5%
Vitreisporites pallidus	1.0%
Disaccites (indet.)	9.0%
Parasaccites sp. (reworked)	+

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MARBURG FORMATION

988ft., 10in.

Grey mudstone Count 200+

Alisporites lowoodensis	0.5%
Anapiculatisporites dawsonensis	0.5%
Anapiculatisporites pristidentatus	0.5%
Annulispora folliculosa	+
Annulispora microannulata	+
Apiculatisporis taroomensis	+
Araucariacites fissus	+
Araucariacites spp. (indet.)	1.0%
Baculatisporites comaumensis	0.5%
Cadargasporites baculatus	0.5%
Cadargasporites verrucosus	0.5%
Calamospora tener	0.5%
Cingutriletes cf. *clavus*	+
cf. *Cingutriletes* sp.	0.5%
Circulisporites parvus	0.5%
Classopollis classoides	56.0%
cf. *Densoisporites* sp.	0.5%
Dictyophyllidites sp.	0.5%
Foveosporites sp.	+
Granulatisporites sp.	0.5%
Inaperturopollenites spp. (indet.)	1.0%
Indusiisporites parvisaccatus	2.0%
Leiotriletes directus	1.0%
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites rosewoodensis	+
Lycopodiumsporites semimuris	+
Neoraistrickia elongata	+
Neoraistrickia sp. (indet.)	0.5%
Nevesisporites vallatus	+
Osmundacidites spp.	9.5%
Perinopollenites elatoides	7.5%
Perotriletes sp.	0.5%
Polycingulatisporites crenulatus	+
Polycingulatisporites mooniensis	0.5%
Punctatisporites spp.	1.0%
Stereisporites perforatus	+
Stereisporites sp. (indet.)	1.5%
Trisaccites variabilis	+
Vitreisporites pallidus	1.5%
Disaccites (indet.)	10.0%
Clavatriletes cf. *hammenii* (? reworked)	+
Parasaccites sp. (reworked)	+

690ft., 5in.

Black carb. mudstone Count 200+

Alisporites cf. *grandis*	+
Alisporites similis	0.5%
Anapiculatisporites dawsonensis	+
Annulispora microannulata	+
Antulsporites varigranulatus	+
Arancariacites fissus	+
Araucariacites spp. (indet.)	2.0%
Cadargasporites baculatus	1.0%
Cadargasporites granulatus	+
Cadargasporites verrucosus	+
Classopollis classoides	36.5%
Classopollis simplex	1.0%
Converrucosisporites sp.	0.5%

Cyathidites minor	0.5%
Cycadopites nitidus	0.5%
Foveosporites sp.	0.5%
Inaperturopollenites spp. (indet.)	5.0%
Ischyosporites marburgensis	+
Leiotriletes directus	1.0%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	+
Lycopodiumsporites semimuris	+
Lycopodiumsporites sp. (indet.)	0.5%
Neoraistrickia elongata	+
Nevesisporites vallatus	0.5%
Osmundacidites spp.	1.0%
Perinopollenites elatoides	41.0%
Perinopollenites sp. (indet.)	0.5%
Podocarpidites sp.	+
Stereisporites sp. (indet.)	1.5%
Trisaccites variabilis	6.5%
Vitreisporites pallidus	0.5%
Disaccites (indet.)	5.0%

578ft., 8in.

Grey carb. mudstone Count 200+

Alisporites cf. *grandis*	+
Alisporites lowoodensis	+
Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Annulispora microannulata	+
Antulsporites varigranulatus	+
Apiculatisporis sp.	0.5%
Araucariacites fissus	0.5%
Araucariacites spp. (indet.)	3.0%
Baculatisporites comaumensis	0.5%
Cadargasporites baculatus	+
Camarozonosporites rudis	0.5%
Classopollis classoides	70.5%
Classopollis simplex	+
Conaletes sp.	0.5%
Cyathidites minor	+
Cyathidites cf. *minor*	+
Cycadopites nitidus	1.0%
Foveosporites moretonensis	+
Foveosporites sp. (indet.)	0.5%
Inaperturopollenites sp. (indet.)	0.5%
Indusiisporites parvisaccatus	1.0%
Leiotriletes directus	3.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites semimuris	+
Lycopodiumsporites sp. (indet.)	+
Osmundacidites spp.	2.0%
Perinopollenites elatoides	0.5%
Podocarpidites sp.	+
Polycingulatisporites mooniensis	+
Stereisporites antiquasporites	1.0%
Stereisporites sp. (indet.)	1.5%
Trisaccites variabilis	0.5%
Verrucosisporites spp.	1.0%
Vitreisporites pallidus	0.5%
Disaccites (indet.)	10.0%
Parasaccites sp. (reworked)	+

530ft., 1in.

Grey mudstone Count 200+

Anapiculatisporites dawsonensis	0.5%
Annulispora microannulata	+
Antulsporites varigranulatus	0.5%
Apiculatisporis sp.	0.5%
Araucariacites fissus	2.0%
Araucariacites spp. (indet.)	4.0%
Cadargasporites baculatus	+
Camarozonosporites rudis	+
Classopollis classoides	58.0%
Classopollis simplex	+
Conaletes spp.	1.0%
Cycadopites granulatus	0.5%
Inaperturopollenites spp. (indet.)	5.0%
Indusiisporites parvisaccatus	0.5%
Leiotriletes directus	4.5%
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites rosewoodensis	+
Lycopodiumsporites semimuris	0.5%
Neoraistrickia elongata	0.5%
Neoraistrickia sp. (indet.)	0.5%
Nevesisporites vallatus	+
Osmundacidites spp.	3.5%
Perinopollenites elatoides	5.5%
Podocarpidites sp.	+
Polycingulatisporites mooniensis	+
Rugulatisporites sp.	0.5%
Stereisporites perforatus	+
Stereisporites sp. (indet.)	1.5%
Vitreisporites pallidus	1.0%
Disaccites (indet.)	8.5%

375ft., 1in.

Grey siltstone Count 200+

Anapiculatisporites pristidentatus	+
Annulispora microannulata	+
Apiculatisporis cf. *globosus*	0.5%
Apiculatisporis sp. (indet.)	1.0%
Araucariacites fissus	4.5%
Araucariacites spp. (indet.)	4.0%
Baculatisporites comaumensis	0.5%
Cadargasporites baculatus	+
Classopollis classoides	60.5%
Classopollis simplex	0.5%
Conaletes spp.	2.0%
Cyathidites minor	0.5%
Cycadopites nitidus	0.5%
Dictyophyllidites mortoni	0.5%
Inaperturopollenites spp. (indet.)	3.0%
Ischyosporites marburgensis	+
Leiotriletes directus	4.0%
Lophotriletes sp.	0.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	+
Lycopodiumsporites semimuris	0.5%
Nevesisporites vallatus	0.5%
Osmundacidites spp.	2.0%
Perinopollenites elatoides	2.5%
Podocarpidites sp.	+
Stereisporites antiquasporites	1.0%
Vitreisporites pallidus	1.0%
Disaccites (indet.)	10.0%
Protohaploxypinus sp. (reworked)	+

267ft., 9in.

Grey shale Count 200+

Alisporites lowoodensis	+
Anapiculatisporites pristidentatus	+
Annulispora microannulata	+
Antulsporites varigranulatus	+
Apiculatisporis sp.	0.5%
Araucariacites fissus	0.5%
Araucariacites spp. (indet.)	1.5%
Baculatisporites comaumensis	0.5%
Cadargasporites baculatus	6.0%
Cadargasporites reticulatus	1.5%
Classopollis classoides	20.5%
Classopollis simplex	+
Cyathidites australis	+
Cyathidites minor	0.5%
Cycadopites nitidus	0.5%
Inaperturopollenites spp. (indet.)	3.0%
Indusiisporites parvisaccatus	2.0%
Ischyosporites marburgensis	+
Leiotriletes directus	5.0%

Lycopodiumsporites austroclavatidites	1.0%
Lycopodiumsporites semimuris	+
Neoraistrickia elongata	+
Nevesisporites vallatus	1.5%
Osmundacidites spp.	3.0%
Perinopollenites elatoides	23.0%
Podocarpidites sp.	0.5%
Polycingulatisporites crenulatus	+
Stereisporites perforatus	0.5%
Stereisporites spp. (indet.)	2.0%
Trisaccites variabilis	0.5%
Vitreisporites pallidus	1.0%
Disaccites (indet.)	25.0%

234ft., 2in.

Grey mudstone Count 200+

Anapiculatisporites dawsonensis	+
Araucariacites fissus	1.5%
Araucariacites spp. (indet.)	2.5%
Baculatisporites comaumensis	+
Cadargasporites baculatus	+
Classopollis classoides	39.0%
Classopollis simplex	+
Cyathidites australis	+
Cyathidites minor	+
Cycadopites nitidus	0.5%
Cycadopites cf. *potoniei*	+
Dictyophyllidites mortoni	+
Duplexisporites problematicus	+
Granulatisporites sp.	0.5%
Inaperturopollenites turbatus	+
Inaperturopollenites spp. (indet.)	4.5%
Indusiisporites parvisaccatus	2.5%
Ischyosporites marburgensis	0.5%
Leiotriletes directus	2.0%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	+
Nevesisporites vallatus	+
Osmundacidites sp.	0.5%
Perinopollenites elatoides	2.5%
Podocarpidites cf. *ellipticus*	+
Stereisporites antiquasporites	+
Trilobosporites antiquus	+
Vitreisporites pallidus	4.0%
Zonalapollenites cf. *segmentatus*	+
Disaccites (indet.)	15.0%
Parasaccites sp. (reworked)	+
Protohaploxypinus sp. (reworked)	+

184ft., 6in.

Dark grey mudstone Count 200+

Alisporites lowoodensis	+
Araucariacites fissus	3.0%
Araucariacites spp. (indet.)	2.5%
Classopollis classoides	11.5%
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	+
Inaperturopollenites turbatus	6.5%
Inaperturopollenites spp. (indet.)	18.0%
Indusiisporites parvisaccatus	1.0%
Leiotriletes directus	4.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	+
Osmundacidites spp.	1.5%
Perinopollenites elatoides	15.0%
Podocarpidites sp.	0.5%
Trisaccites variabilis	0.5%
Vitreisporites pallidus	0.5%
Zonalapollenites dampieri	0.5%
Zonalapollenites segmentatus	1.5%
Disaccites (indet.)	25.0%
Leiosphaeridia sp.	7.0%
Acritarch (*Micrhystridium* sp.)	0.5%

159ft., 9in.

Grey carb. mudstone Count 200+

Alisporites lowoodensis	0.5%
Anapiculatisporites dawsonensis	+
Annulispora folliculosa	+
Araucariacites fissus	1.5%
Araucariacites spp. (indet.)	4.0%
Baculatisporites comaumensis	+
Classopollis classoides	11.0%
Contignisporites sp.	+
Cycadopites nitidus	1.0%
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	+
Inaperturopollenites turbatus	1.5%
Inaperturopollenites spp. (indet.)	23.5%
Indusiisporites parvisaccatus	1.0%
Leiotriletes directus	3.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	+
Nevesisporites vallatus	0.5%
Osmundacidites spp.	3.0%
Perinopollenites elatoides	13.5%
Podocarpidites sp.	+
Staplinisporites caminus	+
Trilobosporites antiquus	+
Trisaccites variabilis	0.5%
Trisaccites sp. (indet.)	0.5%
Vitreisporites pallidus	4.0%
Zonalapollenites dampieri	+
Zonalapollenites segmentatus	0.5%
Zonalapollenites cf. *segmentatus*	0.5%
Zonalapollenites trilobatus	+
Disaccites (indet.)	23.0%
Acritarcha:	
Baltisphaeridium spp., *Micrhystridium* spp.	4.0+
Veryhachium sp.	+
Leiosphaeridia sp.	2.0%

89ft., 5in.

Grey carb. mudstone Count 200+

Anapiculatisporites dawsonensis	+
Apiculatisporis sp. (indet.)	1.0%
Araucariacites fissus	2.0+
Araucariacites spp. (indet.)	1.5+
Baculatisporites comaumensis	0.5+
Classopollis classoides	29.5%
Conbaculatisporites sp.	+
Contignisporites sp.	+
Cycadopites nitidus	0.5%
Dictyophyllidites mortoni	2.5+
Gleicheniidites senonicus	1.0%
Inaperturopollenites turbatus	+
Inaperturopollenites spp. (indet.)	23.0%
Indusiisporites parvisaccatus	0.5%
Ischyosporites marburgensis	+
Leiotriletes directus	6.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites sp. (indet.)	0.5%
Osmundacidites spp.	1.5%
Perinopollenites elatoides	7.5%
Podocarpidites sp.	+
Polycingulatisporites densatus	+
Polycingulatisporites mooniensis	+
Stereisporites sp.	0.5%
Trilobosporites antiquus	+
Trisaccites variabilis	0.5%
Trisaccites sp. (indet.)	0.5%
Vitreisporites pallidus	2.0%
Zonalapollenites dampieri	0.5%
Zonalapollenites segmentatus	+
Disaccites (indet.)	16.5%
Acritarcha:	
Micrhystridium sp.	+
Leiosphaeridia sp.	1.0%

G.S.Q. IPSWICH 9

RACEVIEW FORMATION

946ft., 4in.

Grey carb. mudstone Count 200+

Annulispora folliculosa	1%
Annulispora microannulata	2%
Apiculatisporis spp.	2%
Camarozonosporites rudis	+
Camerosporites clarkei	1%
cf. *Cingutriletes* sp.	1%
Conaletes spp.	3%
Conbaculatisporites sp.	1%
Craterisporites rotundus	1%
Dictyophyllidites mortoni	2%
Duplexisporites problematicus	33%
Foveosporites spp.	3%
Granulatisporites sp.	1%
Inaperturopollenites spp.	2%
Leiotriletes directus	11%
Lycopodiumsporites rosewoodensis	1%
Neoraistrickia sp.	1%
Osmundacidites spp.	9%
Perotriletes sp.	+
Polypodiisporites ipsviciensis	12%
Pustulatisporites blackstonensis	1%
Semiretisporis antiquus	5%
Stereisporites sp. (indet.)	2%
Verrucosisporites spp.	4%
Disaccites (indet.)	1%

939ft., 5in.

Grey mudstone Count 100+

Anapiculatisporites pristidentatus	4%
Anapiculatisporites cf. *pristidentatus*	1%
Anapiculatisporites sp. (indet.)	1%
Annulispora folliculosa	3%
Apiculatisporis sp.	1%
Camerosporites clarkei	1%
cf. *Cingutriletes* sp.	+
Craterisporites rotundus	4%
Cycadopites nitidus	2%
Dictyophyllidites mortoni	6%
Duplexisporites problematicus	22%
Foveosporites spp.	3%
Granulatisporites sp.	1%
Leiotriletes directus	14%
Lycopodiumsporites rosewoodensis	+
Neoraistrickia sp.	1%
Osmundacidites spp.	8%
Polycingulatisporites crenulatus	1%
Polycingulatisporites densatus	1%
Polycingulatisporites mooniensis	1%
Polypodiisporites ipsviciensis	6%
Pustulatisporites blackstonensis	+
Semiretisporis antiquus	2%
Stereisporites antiquasporites	1%
Stereisporites sp. (indet.)	8%
Disaccites (indet.)	8%

926ft., 9in.

Dark grey shale Count 100+

Anapiculatisporites pristidentatus	+
Annulispora microannulata	+
Apiculatisporis globosus	1%
Araucariacites spp. (indet.)	1%
Baculatisporites comaumensis	1%
Chordasporites australiensis	+
Conaletes spp.	2%
Converrucosisporites sp.	1%
Densosporites raceviewensis	1%
Foveosporites sp.	2%
Granulatisporites sp.	1%
Inaperturopollenites spp. (indet.)	7%
Leiotriletes directus	5%
Neoraistrickia cf. *taylorii*	1%
Osmundacidites sp.	1%
Polycingulatisporites crenulatus	1%
Polycingulatisporites sp. (indet.)	1%
Polypodiisporites ipsviciensis	7%
Punctatisporites spp.	2%
Semiretisporis antiquus	3%
Stereisporites sp.	1%
Verrucosisporites spp.	2%
Disaccites (indet.)	59%

878ft., 3in.

Dark grey carb. shale Count 200+

Anapiculatisporites pristidentatus	0.5%
Annulispora microannulata	+
Apiculatisporis cf. *globosus*	+
Conaletes sp.	0.5%
Cycadopites nitidus	12.0%
Cycadopites sp. (indet.)	0.5%
Duplexisporites problematicus	+
Inaperturopollenites spp. (indet.)	4.0%
Leiotriletes directus	3.0%
Polycingulatisporites crenulatus	+
Polycingulatisporites densatus	+
Polypodiisporites ipsviciensis	41.0%
Stereisporites sp. (indet.)	0.5%
Vitreisporites pallidus	3.5%
Disaccites (indet.)	34.5%

824ft., 6in.

Grey mudstone Count 200+

Annulispora folliculosa	+
Apiculatisporis globosus	1.0%
Apiculatisporis sp. (indet.)	0.5%
Conaletes sp.	0.5%
Cycadopites granulatus	0.5+
Cycadopites nitidus	5.5%
Cycadopites sp. (indet.)	0.5%
Cycadopites cf. *potoniei*	0.5%
Densosporites raceviewensis	+
Dictyophyllidites mortoni	1.5%
Duplexisporites problematicus	+
Inaperturopollenites spp. (indet.)	1.0%
Leiotriletes directus	1.0%
Osmundacidites sp.	0.5%
Polycingulatisporites crenulatus	+
Polypodiisporites ipsviciensis	52.5%
Verrucosisporites sp.	+
Disaccites (indet.)	34.5%

797ft., 4in.

Black mudstone Count 200+

cf. *Apiculatisporis* sp.	0.5%
Converrucosisporites sp.	6.5%
Cycadopites nitidus	1.5%
Dictyophyllidites mortoni	2.0%
Duplexisporites problematicus	+
Granulatisporites sp.	27.5%
Inaperturopollenites spp. (indet.)	3.0%
Leiotriletes directus	20.0%
Osmundacidites spp.	3.0%
Polycingulatisporites mooniensis	0.5%
Punctatisporites sp.	10.5%
cf. *Stenozonotriletes* sp.	+
Stereisporites sp.	22.5%
Verrucosisporites sp.	0.5%
Disaccites (indet.)	2.0%

743ft., 3in.

Dark grey shale Count 200+

Annulispora microannulata	+
Apiculatisporis sp.	0.5%
Aratrisporites cf. *scabratus*	+
Araucariacites spp. (indet.)	1.5%
Conaletes spp.	3.5%
Converrucosisporites spp.	1.5%
Cycadopites nitidus	9.5%
Dictyophyllidites mortoni	4.0%
Duplexisporites problematicus	1.0%
Foveosporites sp.	0.5%
Granulatisporites spp.	2.0%
Inaperturopollenites spp. (indet.)	3.5%
Indusiisporites sp.	0.5%
Leiotriletes directus	11.5%
Lophotriletes aff. *bauhiniae*	+
Lycopodiumsporites cf. *austroclavatidites*	+
Lycopodiumsporites rosewoodensis	+
Osmundacidites spp.	5.5%
Polycingulatisporites crenulatus	+
Polycingulatisporites densatus	1.5%
Polycingulatisporites mooniensis	1.0%
Polycingulatisporites sp. (indet.)	1.0%
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	8.5%
Vitreisporites pallidus	0.5%
Disaccites (indet.)	42.0%

HELIDON SANDSTONE

696ft., 8in.

Grey shale Count 200+

Alisporites lowoodensis	+
Apiculatisporis globosus	0.5%
Apiculatisporis spp. (indet.)	1.0%
Araucariacites spp. (indet.)	1.0%
Classopollis classoides	+
Conaletes spp.	6.0%
Dictyophyllidites mortoni	1.5%
Discisporites psilatus	+
Foveosporites moretonensis	+
Foveosporites sp. (indet.)	0.5%
Granulatisporites spp.	1.5%
Inaperturopollenites spp. (indet.)	3.5%
Leiotriletes directus	1.0%
Leiotriletes sp. (indet.)	0.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	1.0%
Lycopodiumsporites semimuris	+
Lycopodiumsporites sp. (indet.)	2.5%
Osmundacidites spp.	2.0%
Perinopollenites elatoides	1.0%
Platysaccus queenslandi	+
Polycingulatisporites mooniensis	0.5%
Stereisporites antiquasporites	+
Stereisporites sp. (indet.)	0.5%
Vitreisporites pallidus	36.5%
Disaccites (indet.)	39.0%

612ft., 7in.

Grey mudstone Count 200+

Alisporites lowoodensis	0.5%
Anapiculatisporites dawsonensis	+
Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Antulsporites varigranulatus	+
Cadargasporites baculatus	+
Cadargasporites reticulatus	+
Ceratosporites helidonensis	0.5%
Cerebropollenites cf. *thiergartii*	+
Classopollis classoides	39.5%
Conaletes spp.	2.5%
Cycadopites nitidus	2.0%
Duplexisporites problematicus	+
Foveosporites sp.	0.5%
Gliscopollis meyeriana	0.5%
Inaperturopollenites spp. (indet.)	10.0%
Leiotriletes directus	2.0%
Lophotriletes sp.	0.5%
Lycopodiumsporites austroclavatidites	+
Lycopodiumsporites rosewoodensis	0.5%
Lycopodiumsporites semimuris	+
Neoraistrickia elongata	1.0%
Osmundacidites spp.	12.5%
Perinopollenites elatoides	10.0%
Polycingulatisporites densatus	+
Polycingulatisporites mooniensis	+
Punctatisporites sp.	0.5%
Stereisporites spp. (indet.)	2.0%
Vitreisporites pallidus	4.5%
Disaccites (indet.)	10.5%
Clavatriletes cf. *hammenii* (? reworked)	+

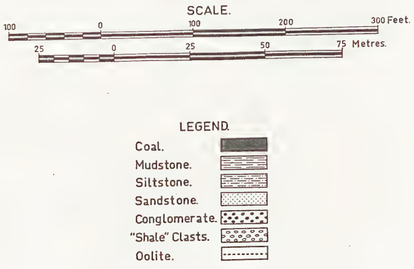
MARBURG FORMATION

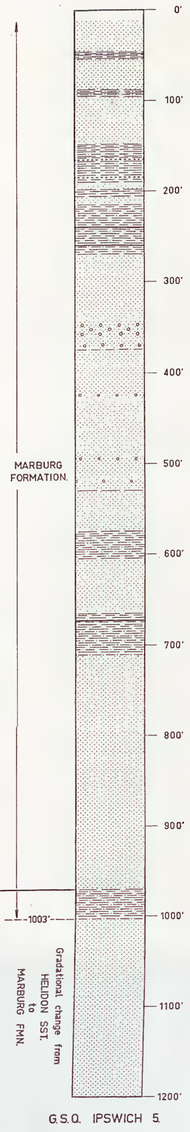
74ft., 7in.

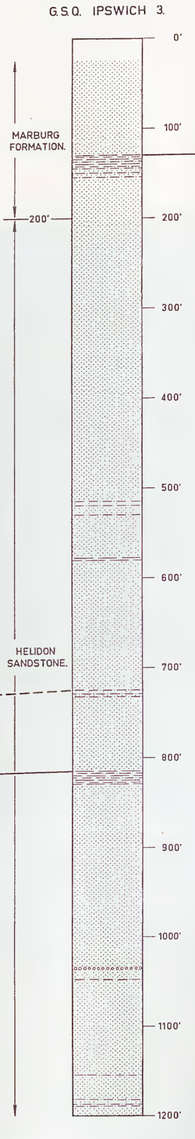
Light grey siltstone Count 200+

Alisporites lowoodensis	+
Anapiculatisporites dawsonensis	+
Annulispora folliculosa	0.5%
Annulispora microannulata	+
Antulsporites varigranulatus	+
Araucariacites spp. (indet.)	0.5%
Cadargasporites baculatus	+
Cadargasporites reticulatus	+
Classopollis classoides	64.5%
Classopollis simplex	0.5%
Conaletes spp.	2.0%
Conbaculatisporites sp.	1.0%
Cycadopites nitidus	1.0%
Dictyophyllidites mortoni	0.5%
Gliscopollis meyeriana	0.5%
Inaperturopollenites spp. (indet.)	3.0%
Ischyosporites marburgensis	0.5%
Leiotriletes directus	2.0%
Lophotriletes sp.	1.0%
Lycopodiumsporites austroclavatidites	0.5%
Lycopodiumsporites rosewoodensis	+
Lycopodiumsporites semimuris	+
Osmundacidites spp.	4.0%
Perinopollenites elatoides	6.0%
Stereisporites perforatus	+
Stereisporites sp. (indet.)	1.0%
Verrucosisporites sp.	0.5%
Vitreisporites pallidus	1.5%
Disaccites (indet.)	9.0%
Parasaccites sp. (reworked)	+
Semiretisporis denmeadi (reworked)	+

FIG. 2: DIAGRAM SHOWING LITHOLOGICAL CORRELATION OF G.S.Q. IPSWICH Nos. 3, 4 and 5, LOWOOD AREA.
(A.R.G. GRAY, PERS. COMM.)







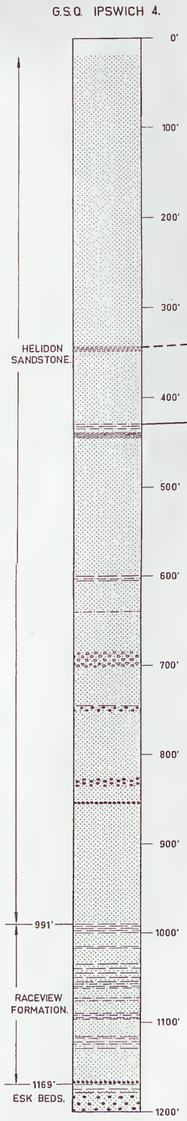
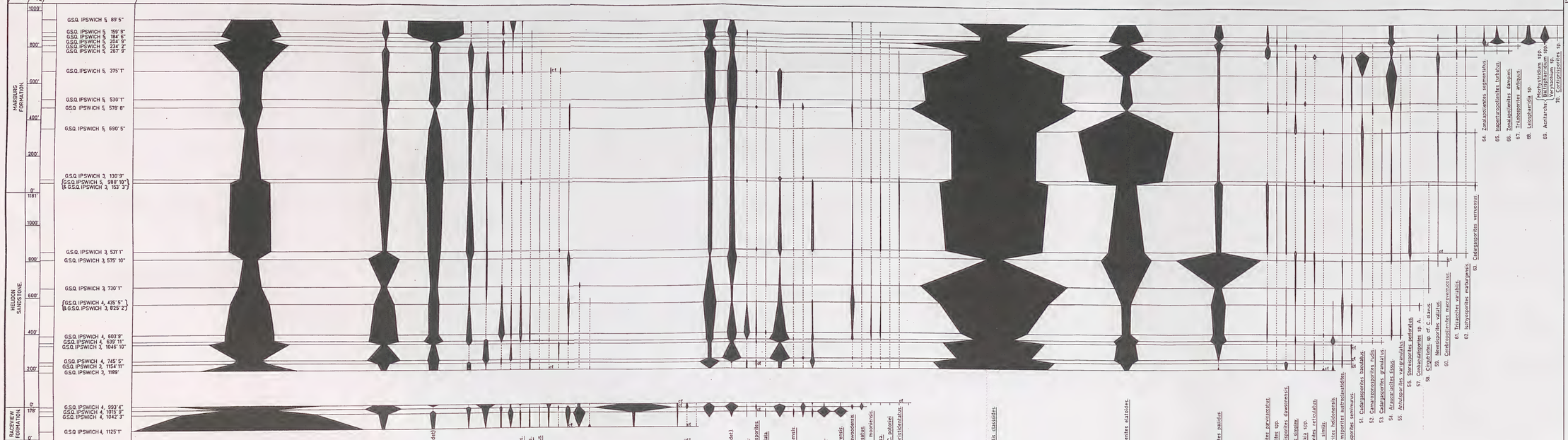


FIG. 3: MICROFLORAL DISTRIBUTION DIAGRAM – COMPOSITE OF G.S.Q. IPSWICH Nos. 3,4 and 5.



N.B. Percentages of spores, pollen and acritarchs are all based on counts of 200 individuals. Assemblages which are closely adjacent stratigraphically and contain large proportions of common species have been combined for easier representation. Average percentages are indicated in such cases.

INDEX TO CHART

Alphabetical List	No. on chart
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Anapiculatisporites pristidentatus.	35.
Annulispora folliculosa.	34.
Annulispora microannulata.	24.
Antulsporites varigranulatus.	55.
Apiculatisporis globosus.	11.
Apiculatisporis spp.	5.
Araucariacites fissus.	54.
Araucariacites spp. (Indet.).	21.
Baculatisporites comaumensis.	8.
Cadargasporites baculatus.	51.
Cadargasporites granulatus.	53.
Cadargasporites reticulatus.	45.
Cadargasporites verrucosus.	63.
Camarozonosporites rudis.	52.
Camerosporites clarkei.	14.
Ceratosporites helidonensis.	48.
Cerebropollenites macroverrucosus.	60.
Cingutriletes. sp. cf. C. clavus.	58.
Classopollis classoides.	38
Classopollis simplex.	44.
Conaletes spp.	25.
Conbaculatisporites sp. A.	57.
Contignisporites sp.	70.
Convertucosisporites camaroni.	18.
Cycadopites magnus.	37.
Cycadopites nitidus.	6.
Cycadopites sp. cf. C. potoniei	35.
Densosporites raceviewensis.	30.
Dictyophyllidites mortoni.	7.
Discisporites psilatus.	10.
Duplexisporites problematicus.	9.
Foveosporites moretonensis.	26.
Foveosporites spp.	13.
Gliscopollis meyeriana.	28.
Inaperturopollenites turbatus.	65.
Inaperturopollenites spp.	3.
Industrisporites parvisaccatus.	41.
Ischyosporites marburgensis:	62.
Leiotriletes directus.	20.
Lophotriletes spp.	12.
Lycopodiumsporites austroclavatidites.	49.
Lycopodiumsporites rosewoodensis.	31.
Lycopodiumsporites semimurus.	50.
Neoraistrickia spp.	45.
Nevesisporites vallatus.	59.
Osmundacidites spp.	2.
Perinopolleites elatoides	39.
Platysaccus queenslandi.	15.
Podocarpidites spp.	42.
Polyingulatisporites crenulatus.	10.
Polyingulatisporites densatus.	32.
Polyingulatisporites mooniensis.	33.
Polypodiisporites ipsoiensis.	16.
Semireltsporis antiquus.	29.
Stereisporites antiquasporites	23.
Stereisporites perforatus.	56.
Stereisporites spp.	4.
Triletosporites antiquus.	67.
Trisacites variablis.	61.
Verrucosisporites spp.	27.
Vitreisporites pallidus.	40.
Vitreisporites microsaccus.	17.
Zonalapollenites dampieri.	66.
Zonalapollenites segmentatus.	64.
Acritarchs (Micrhystridium spp. Baltisphaeridium spp. Veryhachium sp.)	69
Leiosphaeridia sp.	68.
Disaccites (Indet.)	1.

NATIONAL MUSEUM
OF VICTORIA

QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

PUBLICATION No. 352
PALAEONTOLOGICAL PAPERS, No. 26

THE FLORA OF THE KALOOLA MEMBER OF THE BARALABA COAL MEASURES, CENTRAL QUEENSLAND

by

J. F. RIGBY
Geological Survey of Queensland

PALAEONTOLOGICAL PAPERS, No. 27

A SPECIMEN OF *ARAUCARIOXYLON ARBERI* (SEWARD) BEESTON COMB. NOV. FROM QUEENSLAND

by

J. W. BEESTON
Geological Survey of Queensland

BRISBANE
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PALAEONTOLOGICAL PAPERS, No. 26

THE FLORA OF THE KALOOLA MEMBER OF THE BARALABA COAL MEASURES, CENTRAL QUEENSLAND

by

J. F. RIGBY

GEOLOGICAL SURVEY OF QUEENSLAND

SUMMARY

The Upper Permian Glossopteris Flora of the Kaloola Member of the Baralaba Coal Measures is described. The flora of about fifteen species correlates closely with typically Upper Permian floras elsewhere. The described flora is indicative of a cool temperate climate during deposition of the Kaloola Member. Evidence from the plant remains indicates that the tuffaceous sediments were deposited after transport by water.

Isodictyopteridium walkomii gen. et sp. nov. is erected for fructifications of unknown relationship.

INTRODUCTION

The Kaloola Member has been defined by Dear *et al.* (1971, p. 62) as the basal, tuffaceous member of the Baralaba Coal Measures near Theodore, central Queensland. It is rich in plant debris, and easily recognized on the surface. Runnegar (1970, fig. 3) published the name Kaloola Tuff Member without definition for the upper part of the Gyranda Formation, which underlies the Baralaba Coal Measures. His usage followed the concept of Jensen *et al.* (1964, p. 29), who included everything below "the lowest appearance of coal seams or shale rich in carbonaceous plant material" in the Gyranda Formation. Jensen *et al.* (1964, p. 94) considered that both the Gyranda Formation and Baralaba Coal Measures "were deposited in a fluvial and paludal environment".

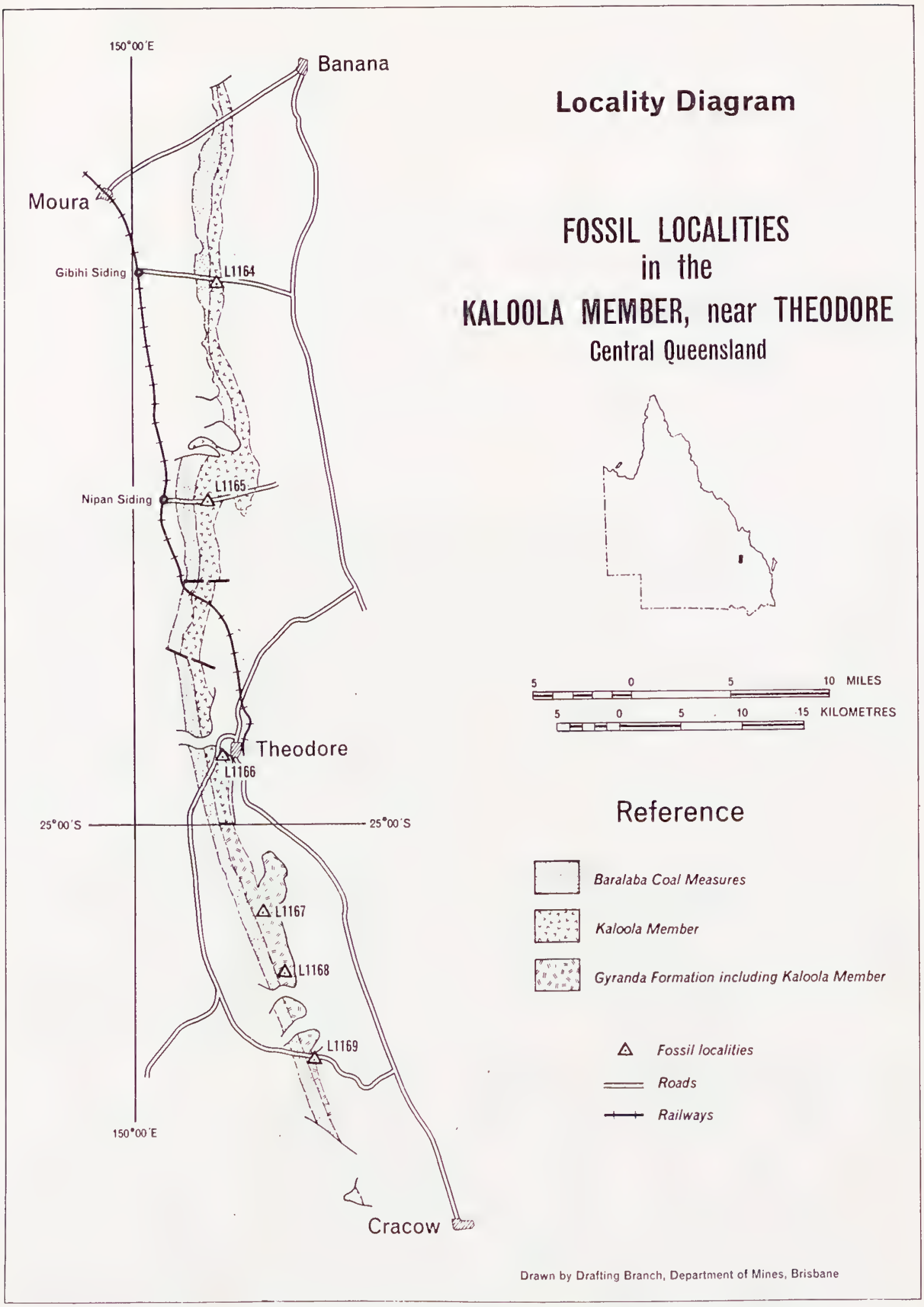
Fossils were collected along 40 miles of outcrop in soil on the surface, the six collecting localities (text fig. A) were selected using information supplied by H. Colton (pers. comm.). Leaves are preserved as impressions in hard, compact blocky fragments of fine grained sediments. These occur more commonly in the soil overlying the stratigraphically lower part of the Kaloola Member, whereas blocks of silicified wood occur in the soil overlying higher parts of the Member. There is an intermediate region where both silicified wood and leaves occurs. Parts of the Member with prolific plant remains alternate with regions of rare or no plant remains along the outcrop (Colton, pers. comm.).

Leafy remains tend to lie horizontally, and are broken but not folded. There do not appear to be any horizons where leaves were deposited in a thick bank over a long period of time. The leaves have been transported by gently flowing water as they are flat; wind-blown leaves and leaves deposited in water subject to wave action become folded and torn raggedly. Silicification of the logs occurred before compaction as the logs are essentially uncompressed. The mechanism of silicification is not clearly understood (see Sen, 1955, and Turnau-Morawska, 1959, for contrasting ideas). The specimen determined as "Fructification cf. *Dictyopteridium* sp." is a compressed cylinder with an ovate section of 5·5 mm x 1·1 mm.

Catalogue numbers of specimens are prefixed as follows to show the repositories: BSIP, Birbal Sahni Institute of Palaeobotany, Lucknow, India; GSI, Geological Survey of India, Calcutta; GSQ, Geological Survey of Queensland, Brisbane; UQ, Department of Geology and Mineralogy, University of Queensland, Brisbane.

DISCUSSION

White (1964c, p. 2) reported from Bureau of Mineral Resources locality T157, 1 mile north-east of Kia Ora Homestead, which is near the GSQ locality L1167 (pl. 1, fig. 1), *Glossopteris damudica* Feistmantel, *G. ampla* Dana, *G. conspicua* Feistmantel, *G. indica* Schimper, *G. angustifolia* Brongniart, *Glossopteris* scale leaves, gangamopteroid small leaves and fragments of the type associated with *Lidgettonia australis, Vertebraria indica* Royle, and *Sphenopteris polymorpha* Feistmantel.



Text fig. A.—Fossil localities in the Kaloola Member, near Theodore, central Queensland. Compiled from Monto 1:250,000 Geological Map (Dear *et al.*, 1971) and Mundubbera 1:250,000 Geological Map (Jensen *et al.*, 1964). South of 25°S latitude, on the Mundubbera 1:250,000 Sheet the Kaloola Member has not yet been differentiated from the Gyranda Formation.

TABLE 1

Localities	L1164	L1165	L1166	L1167	L1168	L1169
Phyllotheca australis Brongniart ..	?	x	..	..	x	..
Paracalamites australis Rigby	..	x	..	x	x	x
Sphenopteris lobifolia Morris	x	x	x	w	x	x
Glossopteris browniana Brongniart ..	x	..	..	x	..	x
G. angustifolia Brongniart	x	x	w	x	x	x
G. indica Schimper	..	..	w	w	?	..
G. communis Feistmantel	x	x	x	x	x	x
G. conspicua Feistmantel	x	..	x	w	x	x
G. damudica Feistmantel	..	..	x	x	..	..
Vertebraria indica Royle	x	x	x	x	x	x
Pointed scale	..	x	w	w	..	..
Fructification cf. *Dictyopteridium* sp. ..	..	..	..	..	..	x
Samaropsis sp.	..	..	w	x	..	..
Noeggerathiopsis-like fragments ..	..	x	..	..	..	x
Silicified wood	x	o	..	x	x	x

TABLE 1—Distribution by localities of species found in the Kaloola Member of the Baralaba Coal Measures—

x species present; ? doubtful example of the species present;

o specimen discussed below by J. Beeston;

w reported by White (1964c, 1966), but not found during this investigation.

White (1966, p. 49) reported from Bureau of Mineral Resources locality BA368, 2 miles south-west of Theodore beside the Theodore–Taroom road, which is near the GSQ locality L1166, *Nummulospermum bowenense* Walkom (seeds), *Glossopteris indica* Schimper, *G. angustifolia* Brongniart, pointed, narrow *Glossopteris* scale leaves, *Vertebraria indica* Royle, *Sphenopteris lobifolia* Morris, and indeterminate wood impressions.

Walkom (1922, p. 41) reported *Sphenopteris polymorpha* Feistmantel, *Vertebraria indica* Royle, and *Noeggerathiopsis Hislopii* (Bunbury) Feistmantel from Kianga. This collection may have come from the Kaloola Member, but may equally as well have come from the upper part of the Baralaba Coal Measures.

No other previous investigations into the flora of the Kaloola Member have been undertaken.

Table 1 shows the distribution of species. White's (1964c) determinations have been included; they do not differ significantly from mine. She reported *Glossopteris ampla,* which I have not seen, but at the time of her investigation the species had not been adequately figured in the literature. Some authors had included specimens similar to my *Glossopteris ? indica* (pl. 1, fig. 5, text fig. D) in *G. ampla.* I cannot comment on her determination of *G. indica,* as I do not know the basis on which she separated it from *G. communis.* These two species are sometimes combined (see Arber, 1905, p. 64), and at other times separated on the basis of certain (as by Maheshwari, 1965a, p. 142, also Srivastava, 1956, p. 7) or unreliable characters. It should be pointed out that the speciation of *Glossopteris* has suffered more than that of most genera from the splitting of a small number of "species" into many by some authors, and lumping of a number of "species" into a few all-embracing "species" by others, largely because of the difficulty of separating species based on botanically unsatisfactory material (Potonié 1900, p. 498). I have preferred a more general description as "pointed scale" for what White has called "*Glossopteris* scale leaves"; hers may or may not be the same as mine. The same applies to her "Gangamopteroid small leaves and fragments of the type associated with *Lidgettonia australis*". There is a wide variety of scales associated with the Lower Gondwana flora; some are parts of reproductive structures, others are of unknown function. The exact differences between *Sphenopteris lobifolia* and *S. polymorpha* are not clear to me, but for the time being I am including her record of *S. polymorpha* under the heading *S. lobifolia.*

This flora is both very uniform along the outcrop of the Kaloola Member at the sites examined, and poor in numbers of species although rich in individual specimens. Rigby (1971b, p. 26) pointed out that there are no remains of herbaceous plants, and that probably only a small proportion of the flora has been preserved.

Rigby (1971b) correlated this flora with the floras of the Newcastle Coal Measures of New South Wales and the Raniganj Stage of India; thus the flora is additional evidence for an Upper Permian age for the Baralaba Coal Measures.

PALAEOCLIMATE

The literature on this subject is extensive, so only aspects directly related to the floras are discussed.

King (1958) suggested that by the late Permian southern Brazil was experiencing a temperate to hot climate, India a temperate climate, and eastern Australia a cold to temperate climate.

Briden (1969) has shown that there were two periods of "rapid" polar change during the Upper Palaeozoic which affected climates of that time. During the Upper Carboniferous, South America passed from high to middle latitude, Australia from middle to high latitude, and India from low to middle latitude. In the Upper Permian, South America passed from middle to low latitude, Australia reverted from high to middle latitude, and India remained in the same middle latitude. These changes supported King's contentions.

Rigby (1971b, p. 26) cited evidence for a cool temperate climate over the Bowen Basin at the time of deposition of the Kaloola Member. Additional evidence includes the absence of larger ferns, other than *Sphenopteris*. Other larger ferns such as *Pecopteris* occur in most parts of the world where a warm or tropical climate has been postulated for the Upper Palaeozoic. *Pecopteris* is not known from any part of the Australian Permian, its nearest occurrence is in the southern part of West Irian (Jongmans, 1940), the equivalent distance of about 18° of latitude to the north-west of Theodore, where the Kaloola Member outcrops. This is about the same palaeolatitude as India (Briden, 1969, fig. 6) where it occurs in the Upper Permian Damuda Series. *Pecopteris* occurs throughout the Lower Gondwana section in Brazil. Thus the presence of *Pecopteris* indicates a middle to low latitude and in consequence, a warm to hot climate. Its general absence, as in Australia, indicates a cool climate.

SYSTEMATIC PALAEOBOTANY

Division SPHENOPHYTA
Order EQUISETALES Dumrow, 1829
Family GONDWANOSTACHYACEAE Meyen, 1969
Genus PHYLLOTHECA Brongniart, 1828

Type species.—*Phyllotheca australis* Brongniart, 1828.

Phyllotheca australis Brongniart, 1828
Pl. 1, fig. 3

Remarks.—A few fragments of leaf whorls occur, none of which are attached to stems. The most complete whorl in the figured example shows leaves fused in the conical sheath, and fused for about one third of their length in the expanded disc. Feistmantel (1890, pl. XIV, figs 2, 3) has figured similar specimens from New South Wales. The leaves recorded here are broader, and the whorls are more completely fused than in specimens of *Phyllotheca indica* Bunbury figured by Surange (1955, pl. 2, fig. 7, pl. 3, figs 16, 17). Some figured specimens of *P. australis* (e.g. by Walkom, 1922, pl. 1, fig. 1) are no different from specimens identified as *P. indica.* I agree with Maheshwari (1968, p. 168) that *P. indica* is a synonym of *P. australis.*

Occurrence.—L1165 and L1168, but probably more extensive as suggested by the wider distribution of stems of *Paracalamites. Phyllotheca australis* is one of the most widely distributed of Permian Gondwana plants.

Division SPHENOPHYTA *incertae sedis*
Genus PARACALAMITES Zalessky, 1932

Type species.—*Paracalamites sibiricus* Zalessky, 1932.

Paracalamites sp.
Pl. 1, fig. 3

Remarks.—Broad sphenopsid stems occur together with *Phyllotheca australis* leaf whorls at L1167. Although they are probably the stems of *Phyllotheca australis,* the leaf whorls are detached so the association cannot be confirmed.

These stems are similar to many stems included in *Neocalamites,* which is a genus based on Mesozoic leaves of a type unknown in the Kaloola Member. Radczenko (1936, pl. 3, fig. 4) identified a similar stem from the Kuznetsk Basin of Siberia as *Paracalamites* sp., but because of palaeogeographical separation they are not regarded as conspecific. *Paracalamites australis* Rigby (1966, pl. 32, fig. 19, pl. 33, figs 20-22) is a species with more coarsely ribbed stems. Differences between internal ribbing shown on internal casts and external ribbing shown on compressed stems or external casts are not known, although they may be sufficient to accommodate the figured stem in *P. australis.*

Occurrence.—L1165, L1167, L1168, and L1169.

Sub-Kingdom TRACHEOPHYTA
Genus SPHENOPTERIS (Brongniart, 1822) Sternberg, 1825

Type species.—*Sphenopteris elegans* (Brongniart, 1822) Sternberg, 1825.

Sphenopteris lobifolia Morris, 1845

Remarks.—This species based on fern foliage has been found in most parts of Gondwanaland. Its filicalean nature has been confirmed by reports of fertile specimens which have been figured by Shirley as *Mertensia* (*Sphenopteris*) *lobifolia* (1902, pl. V) from the Dawson River at Baralaba (?) (probably from the Baralaba Coal Measures), by Dolianiti (1956, pl. 1, fig. 2, pl. 2, fig. 5) from the Tubarao Group at Bainha, Criciuma, SC, Brazil, and by Rigby (1966, pl. 33, fig. 35) from the Irwin River Coal Measures at Bangarra Hill near Mingenew, Western Australia. Other examples of fertile *Sphenopteris* have been reported from Gondwanaland, but not as *S. lobifolia.*

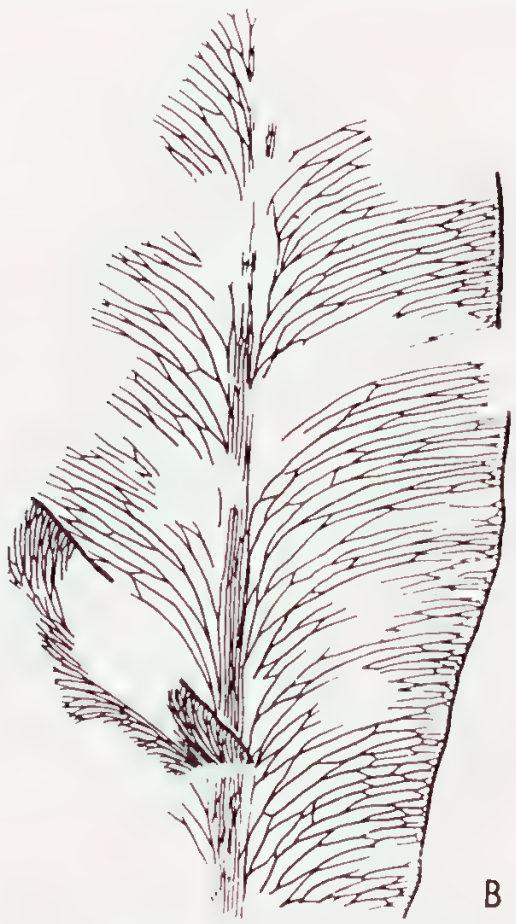
Kulkarni (1970) revised *Sphenopteris polymorpha,* and regarded *S. hughesi* as a synonym. The features distinguishing *S. polymorpha* from *S. lobifolia* are slight. Both *S. polymorpha* and *S. hughesi* appear to be synonyms of *S. lobifolia.*

Occurrence.—L1164, L1165, L1166, L1168, and L1169, and throughout Gondwanaland Permian strata.

Division	GYMNOSPERMAE
Class	CYCADOPSIDA
Genus	GLOSSOPTERIS Brongniart, 1822

Type species.—*Glossopteris browniana* Brongniart, 1822.

Glossopteris browniana Brongniart, 1822



Text fig. B.—*Glossopteris browniana* Brongniart GSQ F11922, fragmentary leaves showing a broad and a narrow example to indicate the variability. The narrow fragment is probably immature. L1167, x 1.

B

Remarks.—This is probably the most widely distributed and variable species of *Glossopteris.* Text fig. B shows parts of a small and large leaf. These appear to be similar to some leaves described by White (1964a, p. 75, pl. 8, fig. 2.2) as large leaves of *G. angustifolia.* Comparison of this with other species identified from the Kaloola Member follows the section on *G. damudica* below.

Occurrence.—L1164, L1167, and L1169. Widely distributed in the Permian and uncommon in the Triassic of Gondwanaland. It is restricted to the Permian in Australia.

Glossopteris angustifolia Brongniart, 1822

Remarks.—Specimens with a leaf shape and venation similar to the examples figured by Zeiller (1896, pl. XVIII, figs 1-3, text figs 14, 15) are included under this species, but the broader leaves included in this species by White (1964a) belong in other species.

Occurrence.—L1164, L1165, L1167, L1168, and L1169. Widely distributed in the Permian and less common in the Upper Carboniferous and Triassic of Gondwanaland. It is restricted to the Permian in Australia.

Glossopteris ? *indica* Schimper, 1869

Pl. 1, fig. 5, text fig. D

Remarks.—Specimen GSQ F11910 from locality L1168 is too fragmentary for definite identification, although it has the typical short, broad areoles next to the midrib, and straight, parallel secondary venation away from the midrib. White (1964c, p. 3; 1966, p. 49) reported but did not figure examples of this species.

Occurrence.—L1168, and near L1166 and L1167 by White (1964c, 1966). Common in the Permian and present in the Triassic of Gondwanaland. It is restricted to the Permian in Australia.

Glossopteris conspicua Feistmantel, 1881

Pl. 1, fig. 6, text fig. E

1881 *Glossopteris conspicua* Feistmantel, p. 104. pl. XXVIII A, figs 1, 5, 6, 8, 9.

1886 *G. conspicua* Feistmantel, p. 29.

1905 *G. conspicua* Feistmantel, in Arber, p. 86-87, pl. 3, fig. 3, text fig. 22.

1922 *G. tortuosa* Zeiller, in Walkom, p. 20-21, pl. 3, figs 15-16.

1928 *G. conspicua* Feistmantel, in Walkom, p. 558-559 (*pars*), text fig. 7 only.

1934 *G. conspicua* Feistmantel, in Robertson, p. 1-2, text figs 1-2.

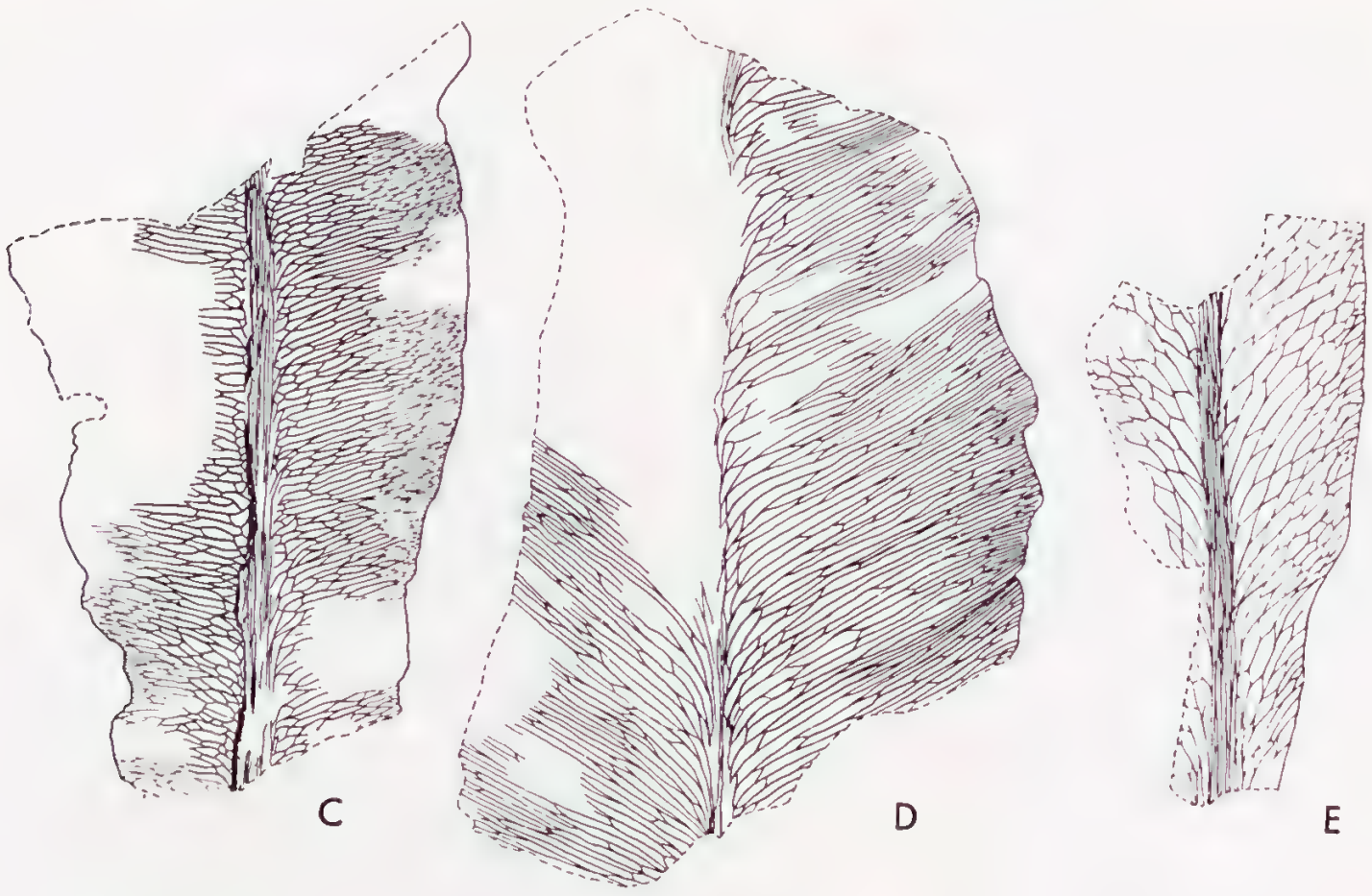
1956 *G. conspicua* Feistmantel, in Srivastava, p. 9-10, pl. 4, figs 21-25, text figs 9-10.

1961 *G. conspicua* Feistmantel, in White (unpubl.), figs 28, 30.

1964a *G. conspicua* Feistmantel, in White, p. 74.

1964c *G. conspicua* Feistmantel, in White (unpubl.), pl. 1, fig. 1.

1966 *G. conspicua* Feistmantel, in White, p. 50-51, pl. B, fig. 2, pl. C, fig. 1.



Text figs C–E.—
(C) *Glossopteris damudica* Feistmantel, GSQ F11921, L1168.
(D) *Glossopteris* (?) *indica* Schimper. GSQ F11919, L1168.
(E) *Glossopteris conspicua* Feistmantel, basal fragment. GSQ F11920, L1167. All natural size.

Remarks.—In the Bowen Basin, this species is limited to the Blackwater Group and equivalent units of Upper Permian age. Determinations by authors have been accepted only when accompanied by a figure, or when I have seen the specimen. The specimen from the Blackwater Group, 2 miles south-west of Kemmis Creek Homestead (at approximately 148° 21′E, 21° 37′S), identified by White (1964a, p. 74) as *G. conspicua,* is identical with the basal portion of a leaf figured by Feistmantel (1881, pl. 28A, fig. 8). Walkom (1922, p. 21) identified a number of specimens from the Blackwater Group and its equivalents of the Collinsville, Blackwater, and Baralaba districts as *G. tortuosa,* a species then known by a single small fragment from the Raniganj Stage at Raniganj, India. Walkom's specimens belong under *G. conspicua.*

Specimens from Transvaal identified as belonging to this species have been omitted as they have a much closer and more frequently anastomosing venation.

Occurrence and Age.—L1166, L1168 and L1169. Elsewhere in Queensland—Baralaba Coal Measures at Baralaba, Blackwater Group at Blackwater and Collinsville; New South Wales—Newcastle Coal Measures at Belmont; India—Barren Measures and Raniganj Stage of the Damuda Division of Bihar; Tanzania—Tanga Beds near Tanga; Antarctica—Buckley Formation of South Victoria Land and Queen Maud Range. The species occurs only in the Upper Permian.

Glossopteris damudica Feistmantel, 1879

Pl. 1, fig. 4, text fig. C

Remarks.—This species is used in the restricted sense of Archangelsky (1958, p. 54), where it is considered as separate from *G. ampla.* White (1964c, p. 3, pl. 1, fig. 2) reported this species from the Baralaba Coal Measures, 1 mile south-west of Gyranda Pumping Station (about 8 miles south-east of my most southerly locality, L1169); despite the small size of the fragments, they are readily recognizable.

I have examined the specimen figured by Ball (1912, pl. 3, fig. 1) as *G. indica,* from Mount Mulligan, north Queensland, and find it is *G. damudica.*

Occurrence and Age.—L1166 and L1167. Elsewhere in Queensland—Baralaba Coal Measures at Gyranda and Baralaba; Blackwater Group at Blackwater, Dingo and Springsure; Mount Mulligan Coal Measures at Mount Mulligan. Widely distributed in the Upper Permian of Gondwanaland and Lower Permian of Argentina. This species may be considered as indicative of Upper Permian in Australia.

TABLE 2

Species*	Shape	Base	Apex	Midrib†	Secondary veins‡	Meshes
Glossopteris browniana Brongniart	Spathulate, oval-lanceolate	Contracted	Obtuse, rounded	Distinct, persistent, possibly disappearing just below the apex	Acute at midrib, oblique, arched strongly or slightly, intersect margin at 45°–90°	Oblong-polygonal, becoming narrower towards the margin. About 5 times as long as broad
G. angustifolia Brongniart	Narrow, linear, less than 2 cm. broad	Petiolate ..	Acute ..	Persistent	Acute, oblique, barely arched, intersect margin at 15°–30°	Narrow elongate-polygonal, up to 3 anastomoses from midrib to margin
G. indica Schimper	Lanceolate, oval-lanceolate, often very large	Petiolate ..	Acute ..	Persistent, stout in lower part	Acute, oblique, unarched to slightly arched	Irregular, short and almost equidimensional next to midrib, then narrow, very elongate
G. communis Feistmantel	Lanceolate, oval-lanceolate, often very large	Petiolate ..	Acute, rounded	Persistent	Acute, oblique, arched, parallel and equally spaced throughout, intersect margin at 20°–45°	Very elongate-polygonal, 1 to 4 anastomoses from midrib to margin
G. conspicua Feistmantel	Spathulate, oval-lanceolate, rarely more than 7 cm. long	Contracted	..	Distinct, may not persist to apex	Acute, oblique, arched, up to 2 mm apart, not persistent from midrib to margin, but branch and fuse with adjacent veins	Elongate hexagonal or polygonal, sometimes becoming smaller towards margin
G. damudica Feistmantel	Broadly ovate ..	..	Obtuse, rounded	Distinct, broad ..	Almost perpendicular after curving rapidly away from midrib. Spaced approximately 1 per mm towards midrib to 2 or more per mm towards margin	Sub-triangular adjacent to midrib, then narrow elongate, becoming much narrower and shorter near margin
The following three species occur in the Baralaba Coal Measures and Blackwater Group, and are similar to some of the above species.						
G. linearis McCoy	Narrow, linear-lanceolate, less than 2 cm. broad	Petiolate ..	Acute, rounded	Distinct, probably persistent	Acute, oblique, slightly arched, intersect margin at 30°–60°	Elongate-polygonal, narrower towards margin, occasionally triangular next to midrib
G. ampla Dana	Broadly ovate ..	Contracted	Broadly rounded, emarginate	Distinct, persistent, up to 1 cm. wide at base	Acute, oblique, arched towards midrib becoming straight and parallel towards margin	Elongate-polygonal, often much narrower and longer towards margin
G. retifera Feistmantel	Lanceolate, oval-lanceolate	Petiolate ..	Acuminate or (?) obtuse	Distinct	Slightly arched, oblique to almost perpendicular, not persistent from midrib to margin, but branch and fuse with adjacent veins, intersect margin at 75°–90°	Slightly elongate hexagonal, becoming narrower and shorter towards margin

NOTES:—

* The following species are often confused:—*G. angustifolia* and *G. linearis*, *G. indica* and *G. communis*, *G. damudica* and *G. ampla*.

† All have striated midribs.

‡ Angles of intersection of veins at margins are measured away from the base and apex where the leaf shape often causes irregularities.

Glossopteris communis Feistmantel, 1876

Pl. 1, fig. 7

Remarks.—This species has often been combined with *G. indica*, following the proposal by Zeiller (1896, p. 368), who could see no valid reason for their separation as there were leaves showing characters grading from one species to the other. Walkom (pers. comm.) had originally examined his *Glossopteris* specimens from Queensland with a view to separating *G. communis* from *G. indica,* but could not find any constant distinguishing features. All of his specimens fall within the limits of *G. communis* as the species is now understood (see Rigby, 1966, p. 130).

Occurrence.—All localities in the Kaloola Member. Common throughout the Permian of Gondwanaland.

Table 2 shows the principal features of the species of *Glossopteris* discussed above. Similar features are tabulated for three other species, which are often confused with the Kaloola Member species, and which are found in the Baralaba Coal Measures and Blackwater Group elsewhere in the Bowen Basin.

Genus VERTEBRARIA Royle, 1833

Type Species.—Vertebraria indica Royle, 1833.

Vertebraria indica Royle, 1833

Remarks.—This very common Permian species has been reported and figured by Walkom (1922, p. 23, pl. 8, figs 43, 44, pl. 9, figs 45, 46) from many parts of Queensland, including Kianga where the Baralaba Coal Measures with the Kaloola Member crop out.

Occurrence.—L1164, L1165, L1166, L1167, L1168, L1169. Common throughout Gondwanaland in all but the lowermost part of the Permian section, rare in the Lower Triassic.

POINTED SCALE

Remarks.—This is a small scale-like plant fragment similar to others reported many times in the Lower Gondwana literature, for example, the "Scale-frond of *Glossopteris*", by Walkom (1922, pl. 1, fig. 5). I consider that insufficient is known of their relationships to say that they belonged to the same plant that bore leaves of *Glossopteris.*

Occurrence.—L1165. Similar scales commonly occur in the Permian of Gondwanaland.

Sub-Kingdom TRACHEOPHYTA

Genus DICTYOPTERIDIUM Feistmantel ex Zeiller, 1902.

Type species.—Dictyopteridium sporiferum Feistmantel ex Zeiller, 1902.

Remarks.—There has been considerable confusion in the application of this generic name to fossil plants. In all cases the name has been used in connection with isolated Lower Gondwana fructifications that show similarities to attached glossopterid fructifications, although it cannot be discounted that the detached fructifications may belong to some other plant genus.

Feistmantel (1881, pp. 7, 14, 34, 47, pl. XXIII A, figs 4–6, 14) figured and named, but did not describe, some specimens as *Dictyopteridium sporiferum,* which bear the numbers GSI 5210–5212, and GSI 5220. Later (1886, p. 34, pl. V A, fig. 3) he figured and named a specimen as *Dictyopteridium* sp., which appears to be specifically distinct (Maheshwari, 1965b, p. 145).

Zeiller (1902, p. 24, pl. IV, fig. 4) validated the name by providing a photograph and description of a specimen. Maheshwari (1965b, p. 145, pl. 1, figs 2–7) figured and described additional specimens, one of which showed that the reverse face was coarsely reticulate, not fertile. His specimens appear to be identical with the specimen described by Zeiller.

Saksena (1962, p. 92, pl. 2, figs 16, 17) included in *D. sporiferum,* a specimen which appears to belong to some genus other than *Dictyopteridium,* as it bears closely packed tubercles instead of having them widely spaced.

All specimens mentioned above were found in the Lower Gondwana of India. Other records have all been from Queensland.

Walkom (1922 p. 36, pl. 9, fig. 48) described specimen GSQ F1904 as *D. sporiferum* and gave a description. His figure is not clear, so it has been reproduced here (text fig. F, 2). He did not figure a second fragment on the same rock which is shown here as text fig. F, 1. These two specimens differ from Zeiller's and Maheshwari's by having a distinct marginal wing, hence they cannot belong to *Dictyopteridium.* They are redescribed below as *Isodictyopteridium walkomii* gen. et sp. nov.

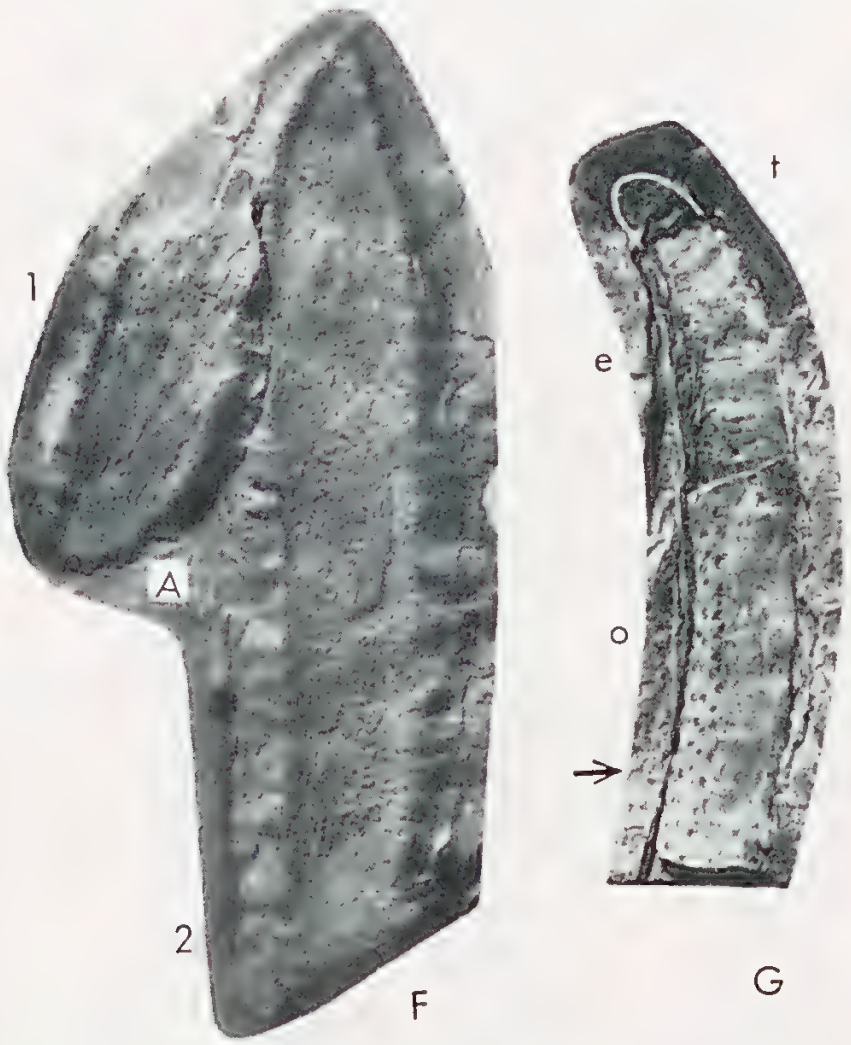
Rigby (1963, p. 345, pl. xi, fig. 3) figured as *D. sporiferum,* specimen UQ F31957 and described it as an isolated glossopterid fructification. It has now been shown (Rigby, 1971a, p. 3–4) to be an example of *Plumsteadia microsacca* attached to a leaf of *Glossopteris communis.*

White (1964b, p. 395, pl. xxiv, fig. 12) figured specimen GSQ F3084 as *"Dictyopteridium sporiferum".* As has been pointed out by White (1964b, p. 395) and Maheshwari (1965b, p. 145), the fragment identified as *Cyclodendron leslii* by Rigby (1963, p. 341, pl. xi, fig. 4) is probably an example of *Dictyopteridium.* I confirm that Rigby's specimen (UQ F42645) belongs in the same species as White's specimen (GSQ F3084). It is not possible to examine the reverse faces of these specimens to see whether they are coarsely reticulate, as in *Dictyopteridium sporiferum,* or tuberculate as in the specimen identified as "Fructification cf. *Dictyopteridium* sp." below. These specimens (White's and Rigby's) differ from *Isodictyopteridium walkomii* (described below) as they do not have a wing, which is present in *I. walkomii.* There is no way of identifying these specimens precisely.

Fructification cf. *Dictyopteridium* sp.

Text fig. G

Description and Remarks.—The only specimen, GSQ F11918 from locality L1169, differs from the Indian specimen BSIP 32872 of Maheshwari (1965b, p. 145, pl. 1, figs 4, 5), which shows a tuberculate obverse and a coarsely reticulate reverse too coarse to be mistaken for a leaf such as *Gangamopteris*. My specimen bears tubercles on both faces of the compressed specimen, which was cylindrical during life. The portion at the lower end of the specimen (see text fig. G), **o**, was removed from the rock to the level →. Tubercles continued around the rear of the organ, still without any regular arrangement. The mould under the cast of the specimen is identical in ornamentation with the exposed part, **e**, which is sparsely covered with ill-defined tubercles. The organ is 5·5 mm wide at the base and 1·1 mm thick. It is quite reasonable to expect this degree of compression of a cylinder in the fine tuffaceous sediments of the Kaloola Member. Rock covering the tip, **t**, was removed during preparation; the shape of the tip is shown by the white line. Its preservation is too poor to form the basis of a new taxon.



Text figs F, G.—

(F) *Isodictyopteridium walkomii* gen. et sp., nov. Two fragments, GSQ F1904, x 2. 1. Basal fragment with pedicel, **A**. 2. Apical fragment, probably lacking only the base, showing the central body bearing numerous tubercles. The central body is bounded by scalloped wings which are continuous except across the base. Walkom (1922, p. 36) gave the locality as Dawson River, which is in the Baralaba Coal Measures.

(G) Fructification cf. *Dictyopteridium* sp., specimen partly in mould, **e**, and partly in cast, **o**. The cast was removed below the arrow, →, and examined on the reverse, which was found to be the same as the obverse. A few tubercles may be seen with difficulty on the mould at **e**. The tip, **t**, was exposed during preparation and has been outlined in white on the figure. GSQ F11918, x 2. L1169.

Genus ISODICTYOPTERIDIUM gen. nov.

Type species.—*Isodictyopteridium walkomii* sp. nov.

Diagnosis.—Linear lanceolate organ bearing numerous irregularly arranged, widely spaced, circular tubercles, superimposed on a fine longitudinal, occasionally anastomosing venation, that arches towards the margin, and passes without interruption into the scalloped wing that surrounds the broadly pedicellate organ. Affinities unknown.

Comparison.—This genus closely resembles *Dictyopteridium* Feistmantel ex Zeiller. The central, tuberculate body is identical, but this is surrounded by a scalloped wing. The gross morphology of *Isodictyopteridium* resembles *Scutum* Plumstead, in that there is a central body surrounded by a scalloped wing, but in *Scutum* the central body is covered with tightly packed sacs, whereas in *Isodictyopteridium* the central body is covered by tubercles too closely spaced to represent the attachments of sacs of similar size.

Origin of name.—isos (Greek) equal, suggesting the close similarity with *Dictyopteridium*.

Isodictyopteridium walkomii sp. nov.

Text figs F, H, and I

1922 *Dictyopteridium sporiferum*, in Walkom, p. 36, pl. 9, fig. 48.

Type specimen.—GSQ F1904. Figured by Walkom, 1922, as pl. 9, fig. 48 in inverted position, (figured here as text fig. F, specimen 2).

Diagnosis.—Linear lanceolate organ at least five times as long as broad, consisting of a central body bounded by a scalloped wing with more or less entire margin, wing width less than half width of central body. Pedicel broad, slightly contracted from central body

Description.—The specimen is a mould. This fructification consists of a linear–lanceolate central body bearing a large number of minute tubercles. Each tubercle is approximately 0·2 mm diameter, spaced 21 to 26 tubercles per 5 mm square, or up to 100 per square cm. The distribution of the tubercles is completely random (see text fig. H). The surface of the central body is completely covered by a fine anastomosing venation that trends longitudinally, and curves towards the side of the central body, which it crosses at an angle of about 30°, then curves sharply to cross the wing (see text fig. H) at right angles. The veins are spaced 6–8 per mm. The wing is scalloped, and is continuous around the fructification except at the base (A, text fig. F, 1). The margin is straight, or almost straight.

Text figs H, I.—*Isodictyopteridium walkomii* gen. et sp. nov.—

(H) Showing distribution of tubercles on specimen GSQ F1904. A typical part of the venation is shown. Scalloping of the wing is omitted. x 2.

(I) Sketch showing cross section of a tubercle. The shaded side corresponds to the rock matrix. Magnification approximately x 75.

In places where tubercles have not been shown on text fig. H there are flakes of carbon up to 0·5 mm thick (text fig. F), which bear a coarse venation. The surface of these flakes is thought to represent the opposite face of the original plant organ which has been compressed and carbonized. As the inferred reverse face lacks any evidence of tubercles, the fructification is interpreted as having a fertile face and a sterile face, as in *Dictyopteridium sporiferum*. The thickness of carbon suggests that the central body may have been oval or almost circular in cross section. The carbon is structureless.

The central body is at least 45 mm long and has a maximum width of 7·5 mm just below the apex. The wing has a maximum width of 2·7 mm near the centre of the fructification (text fig. F, 2), and is narrowest at its apex where it is about 2 mm wide. It appears to be much narrower on the figures, as it is lying at an angle of about 60° to the surface of the specimen. The pedicel is stout, 3·5 mm broad at the base of fragment 1, near the letter A, text fig. F.

Each tubercle as preserved (i.e. on the mould) consists of a low, depressed continuous rim surrounding a second rim. There is a small circular boss in the centre (see text fig. I). The cavity so formed on the living fructification probably contained a sporangium. The tubercles are so closely spaced that even if each sporangium expanded to fill all available space, it would be no greater than 1–2·5 mm long and 0·5 mm broad across its base. These dimensions suggest the organ is microsporangiate.

Comparison.—The genus is monotypic.

Origin of Name.—Named in honour of Dr A. B. Walkom, who originally described the specimen.

Locality.—Dawson River, Lower Bowen Series (Walkom, 1922, p. 36). Reid (1930, p. 76) included this species in the flora of the "Upper Bowen Series". This is in the Baralaba Coal Measures of present nomenclature.

Division GYMNOSPERMAE
Genus SAMAROPSIS GOEPPERT, 1864

Type species.—*Samaropsis ulmiformis* Goeppert, 1864.

Samaropsis sp.

Remarks.—The genus was erected to include any seeds of unknown relationships that were platyspermic, i.e. had planar symmetry, and had a complete or almost complete marginal wing. Seeds having these characters occur in the Kaloola Member. Open nomenclature is used as my specimen is not sufficiently distinctive, and I have not seen the specimens of White (1966).

Occurrence.—L1166, L1167.

Order CORDAITALES
Family CORDAITACEAE
Genus NOEGGERATHIOPSIS Feistmantel, 1879

Type species.—*Noeggerathiopsis hislopii* (Bunbury) Feistmantel, 1879.

Noeggerathiopsis-LIKE FRAGMENTS

Remarks.—Some leaf fragments without any midrib and with closely spaced parallel veins 1 mm or less apart are considered as probable evidence for the presence of *Noeggerathiopsis*.

Occurrence.—L1165, L1169. Common in the Permian of Gondwanaland, present in the Upper Carboniferous occasionally.

SILICIFIED WOOD

Remarks.—A well preserved specimen is described below by J. Beeston.

Occurrence.—L1164, L1165, L1167, L1168, L1169.

ACKNOWLEDGEMENTS

Dr M. V. A. Sastry, Director, Palaeontology Division, Geological Survey of India, kindly supplied information and photographs of specimens described by the late O. Feistmantel. Dr J. M. Dickins, Bureau of Mineral Resources, Canberra, arranged the loan of specimens from the Commonwealth Palaeontological Collection. Professor D. Hill, Department of Geology and Mineralogy, University of Queensland, arranged the loan of specimens from the University collection.

LOCALITIES

Collections were made at the following localities which have been given registered Geological Survey of Queensland numbers, in sequence from north to south. Their position is shown on the locality map, text fig. A.

L1164—Twenty-six miles north of Theodore, and ½ mile north of the type section of the Kaloola Member, on the south side of the road running east from Gibihi siding. Monto 1:250,000 Sheet at reference 296936; 24° 38′S, 150° 4′E. (Pl. 1, fig. 2).

L1165—Twelve miles north of Theodore, and 1½ miles east of Nipan station, on both sides of the road. Monto 1:250,000 Sheet at reference 295918; 24° 47′S, 150° 3′E.

L1166—West of Theodore, just south of bridge over Palm Creek on Theodore–Taroom Road, in a small quarry to the east of the road, above the pumping station. Monto 1:250,000 Sheet at reference 297895; 24° 58′S, 150° 4′E.

L1167—Seven and a-half miles south of Theodore, and ½ mile north of Kia Ora Homestead, at 25° 3′S, 150° 5′E, Mundubbera 1:250,000 Sheet. This is in the same general region as plant locality T157 of the Bureau of Mineral Resources (Pl. 1, fig. 1).

L1168—Eleven miles south of Theodore, on east side of ridge, 4 miles east of Isla Plains Homestead, at 25° 7′S, 150° 6′E, Mundubbera 1:250,000 Sheet.

L1169—Fourteen and a-half miles south of Theodore, 100 yards south of Dawson Creek Road, 1 mile east of Hillview Homestead, at 25° 10′S, 150° 8′E, Mundubbera 1:250,000 Sheet.

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EXPLANATION OF PLATE 1

(Figures 3–7 are natural size)

Figure 1—Locality L1167, half a mile north of Kia Ora Homestead looking north. north-east. Silicified wood occurs in the foreground lying on the ground, leafy remains occur in all rocks in the middle distance and background.

Figure 2—Locality L1164, on the south side of track running east from Gibihi siding, looking west. All rocks are fossiliferous, some appear to be more or less *in situ*.

Figure 3—*Paracalamites* sp., on left side, GSQ F11924. A longitudinally striated stem. *Phyllotheca australis* Brongniart, on right side, GSQ F11925. Whorl of leaves, partly free and partly fused. L1167.

Figure 4—*Glossopteris damudica* Feistmantel, GSQ F11921, L1168. The secondary venation is almost at right angles to the midrib.

Figure 5—*Glossopteris* ? *indica* Schimper, GSQ F11919, L1168. The fragment has large areoles next to the midrib and the typical straight course of the secondary venation.

Figure 6—*Glossopteris conspicua* Feistmantel, GSQ F11920, L1167. A basal fragment.

Figure 7—*Glossopteris communis* Feistmantel, GSQ F11923, L1167.

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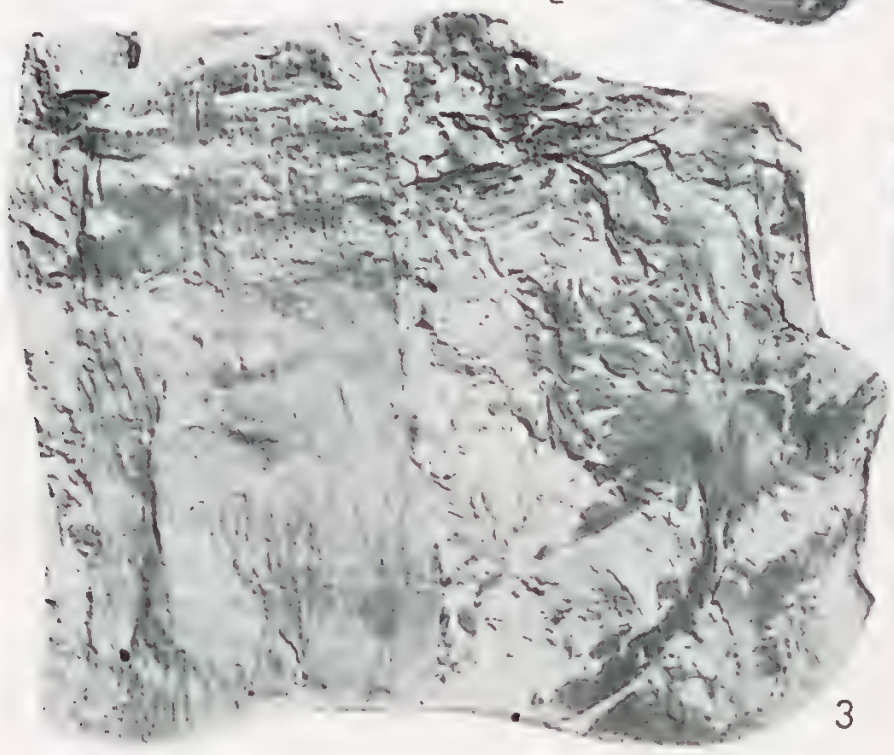

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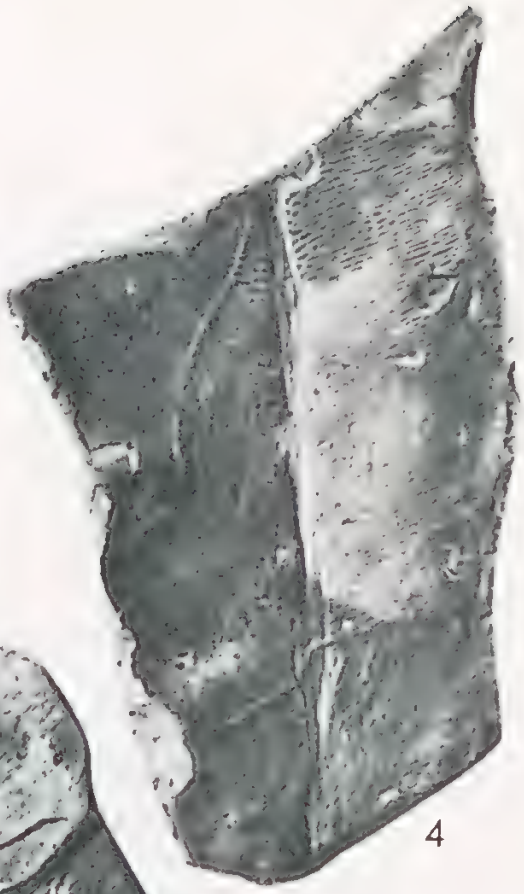

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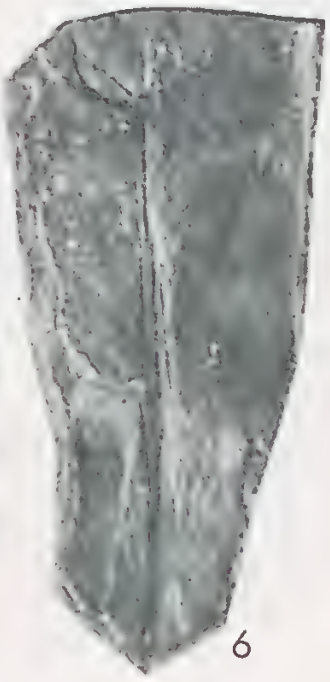

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PLATE 1

PALAEONTOLOGICAL PAPERS, No. 27

A SPECIMEN OF *ARAUCARIOXYLON ARBERI* (SEWARD) BEESTON COMB. NOV. FROM QUEENSLAND

by

J. W. BEESTON

GEOLOGICAL SURVEY OF QUEENSLAND

SUMMARY

Silicified wood from the Upper Permian Kaloola Member of the Baralaba Coal Measures is conspecific with specimens previously determined as *Dadoxylon arberi* Seward, 1919. As primary wood structures are not preserved, the species is more appropriately included in the form genus *Araucarioxylon* Kraus, 1870, and is here recombined as *Araucarioxylon arberi* (Seward) Beeston comb. nov.

INTRODUCTION

Well preserved fossil wood was discovered recently during field work in the Theodore area, Central Queensland. The locality is 1½ miles along the road running east from Nipan Siding, Monto 1:250,000 Sheet, 24° 47′S, 150° 3′E (L1165), within the outcrop of the Kaloola Member of the Baralaba Coal Measures (Rigby, this Publication). The specimen described (GSQ F11917) is indistinguishable from specimens previously determined as *Dadoxylon arberi* Seward, 1919. Reasons for considering that this species should be more appropriately included in *Araucarioxylon* Kraus, 1870 are advanced below.

The fossil wood was studied using orientated thin sections etched with dilute hydrofluoric acid for 10 minutes, stained in a concentrated solution of safranin for about 12 hours, and mounted in Canada balsam. Stained acetate peels proved unsuccessful.

SYSTEMATIC DESCRIPTION

Division	PTEROPHYTA
Class	GYMNOSPERMAE
Genus	ARAUCARIOXYLON Kraus, 1870

Type species.—*Araucarioxylon carbonaceum* (Witham) Kraus, 1870, Carboniferous, England.

Generic Diagnosis.—Growth rings distinct or indistinct; prosenchymatous cells porate; pores large and round, rarely uniserial, adjoining; frequently multiserial, spirally arranged, mutually compressed, hexagonal; resin cell ducts absent; radial medullaries only rarely multiseriate (Kraus, 1870, p. 380).

Discussion.—Kraus (1864, p. 173) described wood of araucarian type resembling the genera *Araucaria* and *Dammara*. In 1870, he formally defined the wood as *Araucarioxylon*.

Arber (1905, p. 190) restricted *Dadoxylon*-type woods of Mesozoic age to *Araucarioxylon*, and those of Palaeozoic age to *Dadoxylon*, apparently ignoring the fact that the type species of *Araucarioxylon, A. carbonaceum*, was described from the Carboniferous of England. Some subsequent authors have followed Arber's usage.

Lepekhina and Yatsenko-Khmelevsky (1966, p. 67) subdivided Palaeozoic woods of *Dadoxylon*-type, which show only secondary wood structures, into five form genera. For one of these, *Araucarioxylon*, they gave the following characteristics:—

> "Tracheid radial pitting of araucarian type; cross-field pits cupressoid; spiral thickenings in tracheids absent, tangential and horizontal walls of ray cells smooth and unpitted".

In this paper, *Araucarioxylon* is used in the same sense as Lepekhina and Yatsenko-Khmelevsky, for specimens formerly included in *Dadoxylon*, but with primary wood structures not retained. In the description of *Araucarioxylon carbonaceum* there is no mention of primary structures.

Sahni and Singh (1926), described several specimens of *Dadoxylon arberi* from the Newcastle Coalfield, New South Wales. These specimens show primary bundles projecting into the pith. However, neither protoxylem nor secretary cells are preserved. Walton (1925) described a specimen from South Africa showing distorted secretary cells in the pith, but without protoxylem preserved. Neither Sahni and Singh's nor Walton's specimens, therefore, shows enough primary wood structure to be identified as *Dadoxylon*. Walton (1925, p. 5) stated "When any wood with well-preserved primary structure and possessing the *D. arberi* type of secondary wood is found, it must be given a distinct name".

The wood from Theodore does not show primary structures, thus the species can no longer be included in *Dadoxylon*, but must be transferred to *Araucarioxylon*.

Araucarioxylon arberi (Seward) Beeston, comb. nov.
Pl. 2, figs 1–9; Pl. 3, figs 1–12

1905 *Dadoxylon australe* Arber, p. 191–199, pls 40–43, *non* Crié (1889).

1912 *Dadoxylon australe* Arber, in Warren, p. 347–355, pls 25–27.

1917 *Dadoxylon nicoli* Seward, p. 255–256, *non* Carruthers (1880).

1919 *Dadoxylon arberi* Seward, p. 178.

1923 *Dadoxylon bakeri* Walton, in Seward and Walton, p. 325–328, pl. 22, figs 19–22, text figs 4, 5.

1925 *Dadoxylon arberi* Seward, in Walton, p. 2–7, pl. 1, figs 1–6.

1926 *Dadoxylon arberi* Seward, in Sahni and Singh, p. 103–112, pls 1–3.

1928 *Dadoxylon arberi* Seward, in Walkom, p. 266.

1928 *Dadoxylon arberi* Seward, in Kräusel, p. 44.

1956 *Dadoxylon nicoli* Seward, in Walton, p. 165–167.

1962 *Dadoxylon arberi* Seward, in Kräusel, Maithy, and Maheshwari, p. 102, fig. 22.

Material.—Arber's co-types 51479, 51434, 51616, 51476, 51503, 51461, and V8299 from the Nicol Collection, British Museum, are from Australia, probably near Newcastle (Arber, 1905, p. 191). The single specimen (GSQ F11917) described in this paper is silicified, in part opalised, and slightly distorted. It consists of a short piece of branch, about 5 cm long and about 10 cm in diameter, with the pith, secondary wood, and a small branch preserved.

Specific Diagnosis.—Pits on radial walls of tracheids tetraserial to uniserial, compressed, alternating; medullary rays uniserial or partly biserial with 1–20 cells; cross-field pits simple, round to oval, closely spaced, 2–10 in each cell.

Text fig. 1. A histogram showing the range and frequency of the number of cells per medullary ray in *Araucarioxylon arberi* (Seward) Beeston comb. nov. from Queensland, specimen GSQ F11917.

Description.—The secondary wood shows up to 22 well defined growth rings spaced ½–4 mm apart (Pl. 2, fig. 5). Tracheids are more or less square to rectangular in cross-section, with about 25 per mm measured tangentially, having an average radial diameter of 22 microns in the spring wood and 13 microns in the autumn wood (Pl. 2, fig. 1). In places the cells have been distorted and partly destroyed by the formation of silica spherulites and crystal aggregates during silicification (Pl. 2, figs 2, 3).

The slightly distorted pith cavity is elliptical, 4 x 3·5 mm. It contains relatively large rounded pith cells which range in diameter from 20 to 70 microns, with an average diameter of 50 microns (Pl. 3, fig. 1). Although both the secondary wood and pith have been preserved, primary wood has not survived.

Medullary rays are abundant, uniseriate, occasionally partly biseriate, with an average of 2 to 5 cells (text fig. 1). The ray cells are cylindrical to subcylindrical, slightly compressed, with an average diameter of 16·5 microns (Pl. 3, figs 3, 4, 6).

Pits in the horizontal walls of the wood tracheids are simple, rare, round to oval, with an average diameter of 4·4 microns, closely spaced, up to 9 in a cell (Pl. 2, fig. 6). Pits in the tangential walls are bordered, uniserial, rare; when spaced they are rounded to oval, when compressed vertically they are hexagonal, with an average diameter of 4·5 microns (Pl. 3, figs 11, 12). Pits in the radial walls are bordered, numerous, uniseriate to tetraseriate, most commonly biseriate (Pl. 3, figs 5, 7, 9, 10). They are arranged alternately, compressed hexagonal, or more rarely opposite and subrounded, with an average diameter of 5·4 microns. Cross-field pits are simple, closely spaced, in oblique rows or subradially arranged. They are round to oval, with 2–10 per cell and having an average diameter of 4 microns (Pl. 3, fig. 8).

A cross-section of the branch shows a central pith cavity, traces of primary xylem, and secondary tracheids (Pl. 2, fig. 4). Pits in the tracheids are bordered, subrounded, biseriate, compressed (Pl. 2, fig. 9). Annular thickening is present in the primary wood in the form of bands about 1 micron broad, spaced about 4 microns apart (Pl. 2, figs 7, 8).

The cell walls of the wood tracheids are about 7·5 microns thick. They have been only very slightly eroded. In places they have parted from the middle lamella, which is also well preserved (Pl. 2, figs 1–3).

An additional feature in specimen GSQ F11917, that has not been observed in *Araucarioxylon arberi* before, is the presence of pits in the horizontal and tangential walls of the tracheids (Pl. 2, fig. 6; Pl. 3, figs 11, 12). Walton (1925) and Sahni and Singh (1926) stated that pits occurred on the radial walls only. Their specimens also differed in having larger bordered pits and cross-field pits, larger tracheids, and

TABLE 1

Comparison of dimensions of specimen F11917 of *Araucarioxylon arberi* (Seward) comb. nov. from Queensland, with the specimens from New South Wales and South Africa

DIMENSIONS	GSQ F11917, this paper	Sahni and Singh's specimen (1926) from N.S.W.	Walton's specimen (1925) from S. Africa
Pith diameter	3·5 x 4·0 mm	30 mm	5 mm
Pith cell diameter	20–(50)–75	(not recorded)	(not recorded)
Maximum width of secondary wood preserved	90 mm	55 mm	(not recorded)
Number of growth rings preserved	22	14	(not recorded)
Width of growth rings	0·5–4·0 mm	1·75–3·5 mm	5–12 mm
Radial diameter of tracheids—			
In spring wood	22 microns	48 microns	30–40 microns
In autumn wood	13 microns	16 microns	8–20 microns
Diameter of pits in tracheid walls—			
In horizontal walls	4·4 microns	(not observed)	(not observed)
In tangential walls	4·5 microns	(not observed)	(not observed)
In radial walls	5·4 microns	10·6–11·7 microns	8–12 microns
Number of pits in cross-field	2–9	2–10	1–9
Diameter of pits in cross-fields	4 microns	5 x 7 microns	3–8 microns
Number of rows of radial wall pits	1–4	1–4	1–4
Number of cells in medullary rays	1–(2–5)–11	1–(12)–20	1–20
Diameter of medullary cells	16·5 microns	(not recorded)	26 microns
Diameter of branch	4·3 x 3·4 mm	15 mm	(not recorded)
Diameter of branch pith	2·1 x 1·1 mm	9 x 5 mm	2 mm

more cells in the medullary rays. The pith cavities in their specimens are also much larger. These differences in size, however, are not significant (Table 1).

Comparisons.—The species *Araucarioxylon maitlandi* Shirley, 1898, *A. binneyi* Shirley, 1898, and *A. williamsoni* Shirley, 1898, possibly have priority over *A. arberi,* but the specimens are poorly preserved, and descriptions based on them are inadequate for specific differentiation.

Sahni and Singh (1926, p. 105) stated that *Araucarioxylon daintreei* Chapman, 1904 is probably not different from *A. arberi.* Maithy (1968, pp. 145–147) re-examined the specimens of *A. daintreei* and considered it to be a separate species, based on differences in type, arrangement, shape and number of the cross-field pits.

Walton (1925, p. 2) doubtfully included a specimen of *Dadoxylon* cf. *angustum* Felix figured by Halle (1911, p. 180) in his synonymy of *Dadoxylon arberi.* The specimen was subsequently redetermined by Lepekhina and Yatsenko-Khmelevsky (1966, p. 68) as *Zalesskioxylon angustum.*

Araucarioxylon arberi shows some similarities to the genus *Antarcticoxylon* Seward, 1914. However, *Antarcticoxylon priestleyi* Seward, 1914 (Seward, 1914, pp. 17–22) and *Antarcticoxylon* sp. cf. *A. priestleyi* (Schopf, 1962, pp. 21–25) differ from *Araucarioxylon arberi* by having fewer, more widely spaced bordered pits and larger and fewer cross-field pits.

The secondary wood of *A. arberi* also shows some similarities to the secondary wood of *Dadoxylon manieroi* Kräusel and Dolianiti (1958), but *D. manieroi* differs in having fewer, more compact bordered pits, larger cross-field pits, and commonly resin canals.

Distribution.—*Araucarioxylon arberi* is restricted to the Permian, and has been found in the Kaloola Member, Baralaba Coal Measures of Queensland, the Sugar Loaf Range, near Newcastle, New South Wales (Sahni and Singh, 1926, p. 105), the Lower Beaufort Beds of South Africa (Walton, 1925, p. 7), the Lafonian System of the Falkland Island (Halle, 1911, p. 141), and the "Coal Shale Group", Lower Shire region, Malawi (Walton, 1956, p. 159).

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EXPLANATION OF PLATE 2

FIGS 1–9. *Araucarioxylon arberi* (Seward) comb. nov. Specimen GSQ F11917, slide a—radial longitudinal section, slide b—tangential longitudinal section, slides c, d, e—cross-sections.

Fig. 1. Slide c; typical form of tracheids, medullary rays (shown in longitudinal tangential section), and traces of middle lamellae in secondary wood. In places the middle lamellae can be seen separated from the tracheid walls, x 200.

Figs 2, 3. Slide c; distortion of the tracheids caused by the formation of silica spherulites and crystal aggregates, x 200.

Fig. 4. Slide c; cross-section of a minor branch showing pith, traces of primary wood, secondary wood, and secondary wood of main branch, in which pits in the horizontal tracheid walls can be seen. Note growth rings on centre right, x 10.

Fig. 5. Slide e; part of a growth ring, showing autumn and spring wood, x 50.

Fig. 6. Slide c; irregularly arranged simple pits in the horizontal walls of the wood tracheids near the branch trace, x 500.

Fig. 7. Slide c; tracheids showing annular thickening in the wood of the minor branch, x 200.

Fig. 8. Same, showing the shape, arrangement and spacing of the individual bands of thickening, x 500.

Fig. 9. Slide c; pits in the tracheids of the minor branch, showing tendency towards biserial arrangement, x 500.

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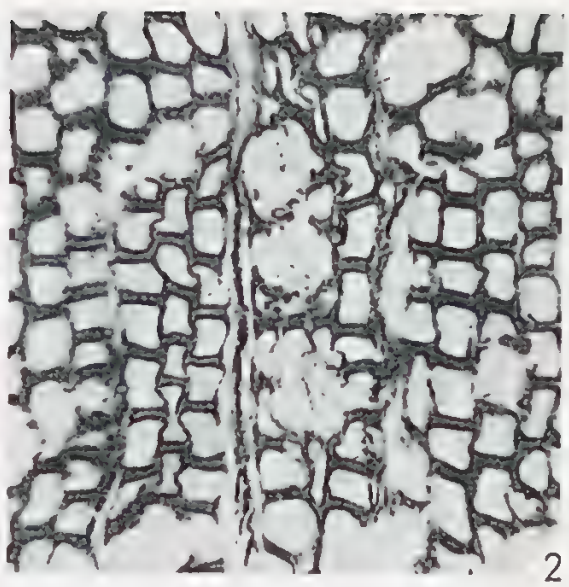
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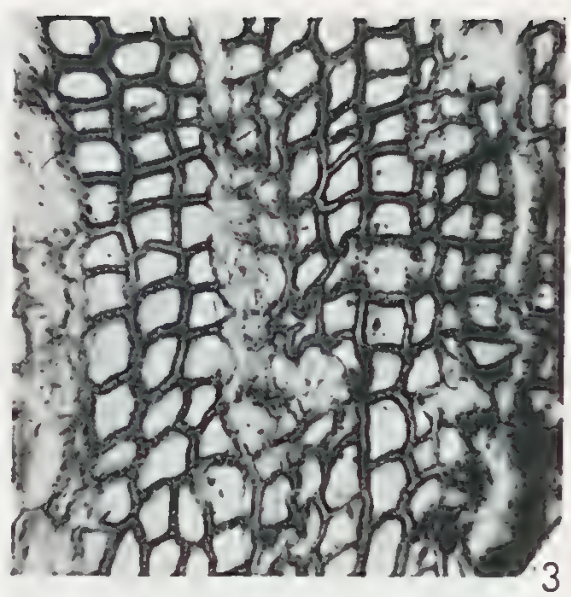
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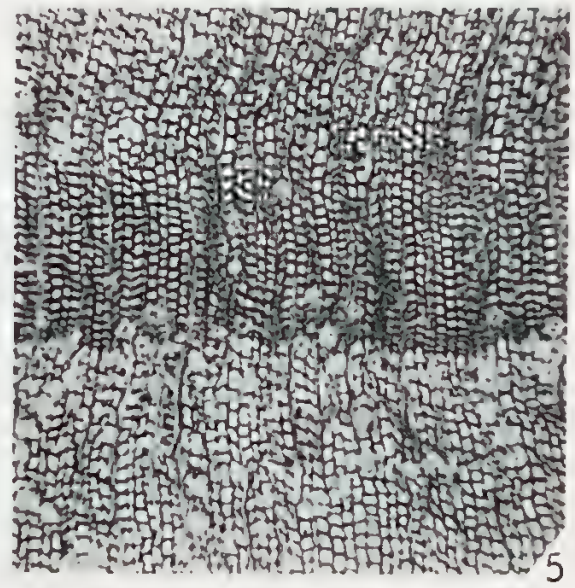
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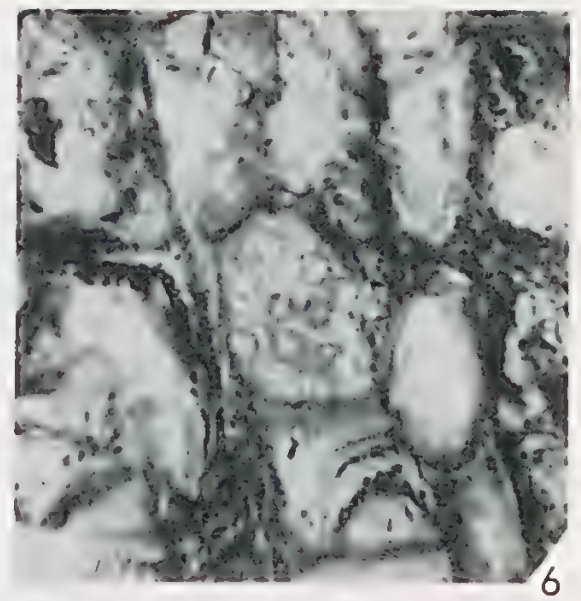
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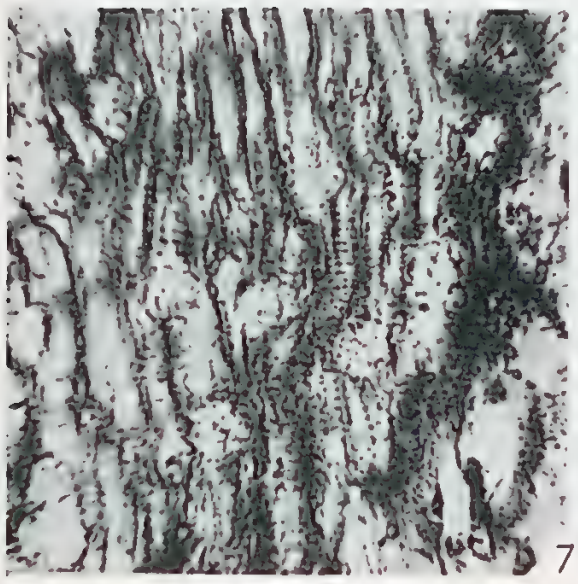
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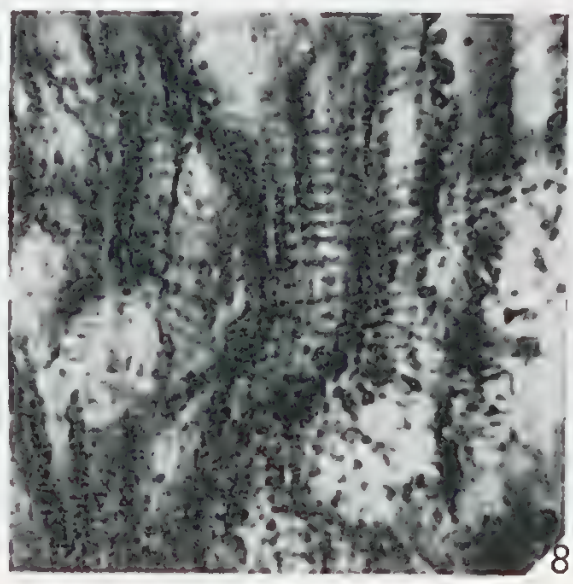
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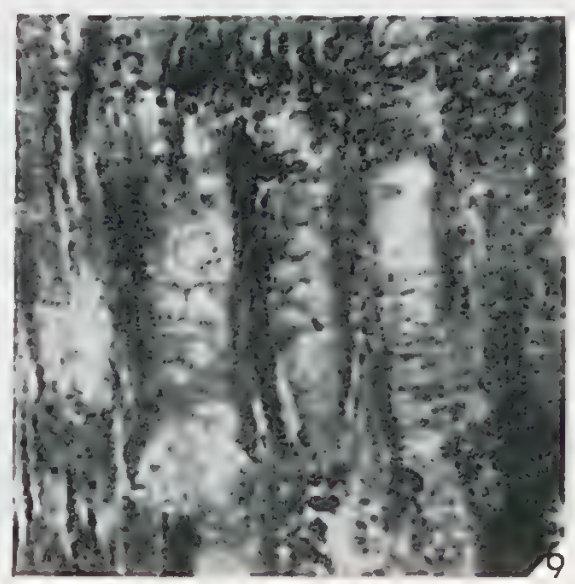
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PLATE 2

EXPLANATION OF PLATE 3

FIGS 1–12. *A. arberi* (Seward) comb. nov. Specimen GSQ F11917 (For details of slides, see Explanation of Plate 2).

Fig. 1. Slide d; pith cells, remains of distorted primary wood, and early secondary wood; x 50.

Fig. 2. Slide d; pith cells, showing size variation, and arrangement of the cells, x 200.

Fig. 3. Slide b; cross-section, showing the uniserial arrangement of the medullary ray cells, x 200.

Fig. 4. Slide a; longitudinal view of the medullary rays, showing arrangement and also the extent and arrangement of the tracheids, x 50.

Fig. 5. Same, showing the abundance and general arrangement of the bordered pits in the tracheid radial walls, x 200.

Fig. 6. Slide b; cross-section of the medullary rays, showing distribution and size, x 50.

Fig. 7. Slide a; transverse, radial section, showing biseriate, rounded, adjacent pits in the radial walls of the tracheids, x 500.

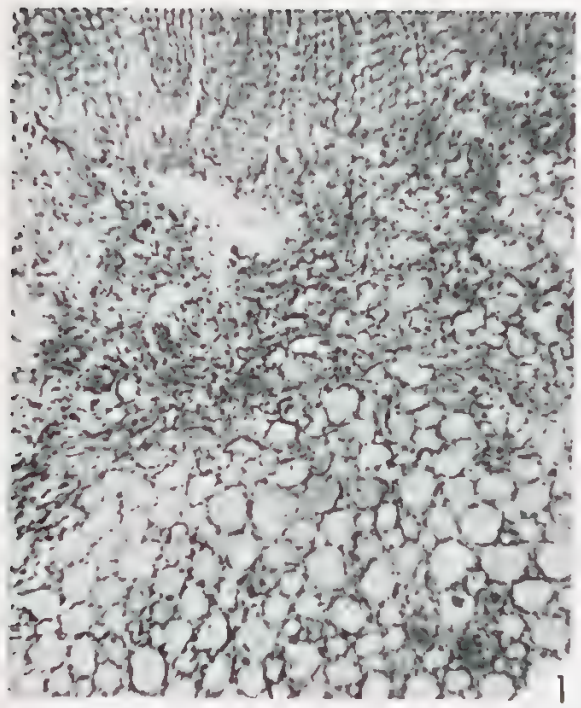
Fig. 8. Same, showing the radially arranged, simple pits in the cross-fields, x 500.

Fig. 9. Same, showing triseriate and tetraseriate, partly compressed, alternating hexagonal bordered pits in the radial tracheid walls, x 500.

Fig. 10. Same, showing biseriate, compressed, alternating hexagonal bordered pits in the radial tracheid walls, x 500.

Fig. 11. Slide b; compressed, uniseriate pits in the tangential tracheid walls, x 500.

Fig. 12. Same, showing slightly spaced, rounded, uniseriate pits in the tangential tracheid walls, x 500.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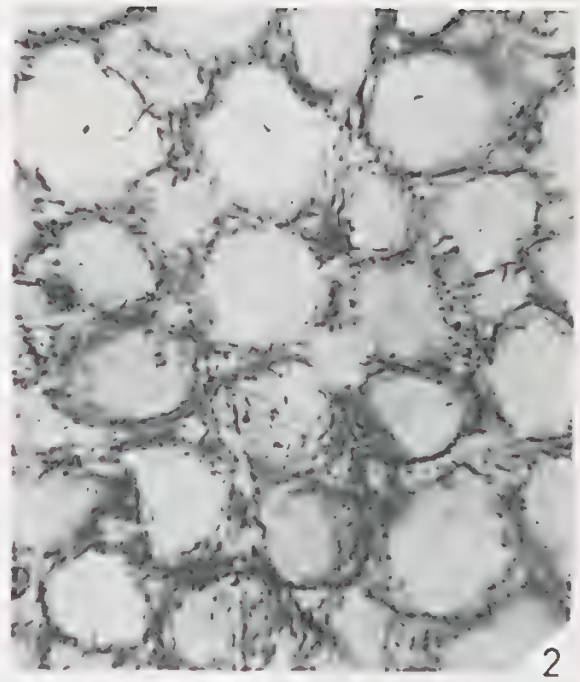
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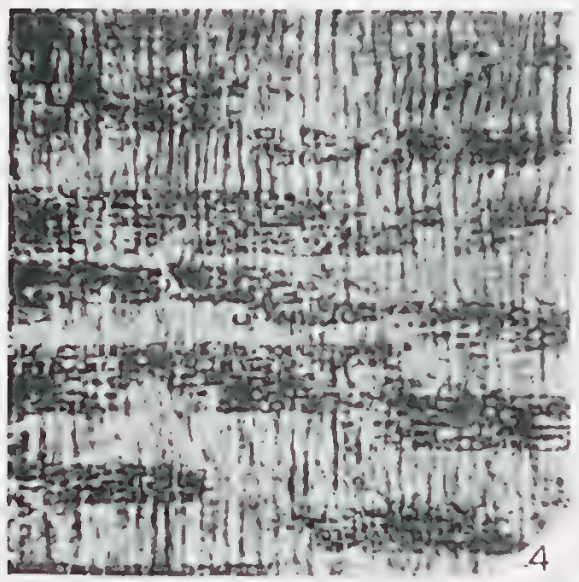
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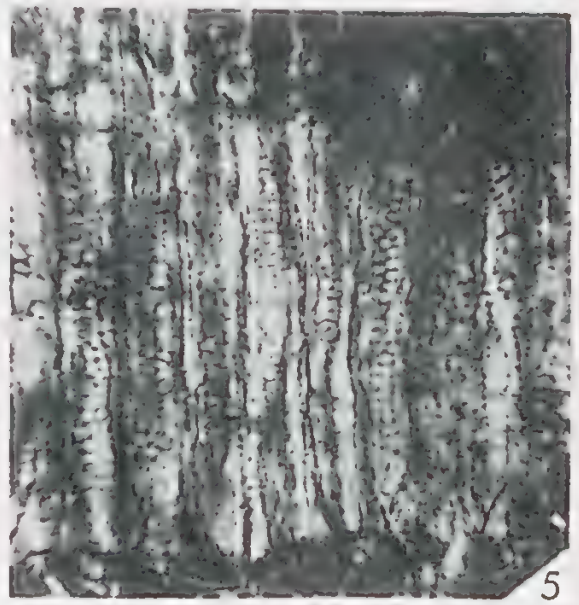
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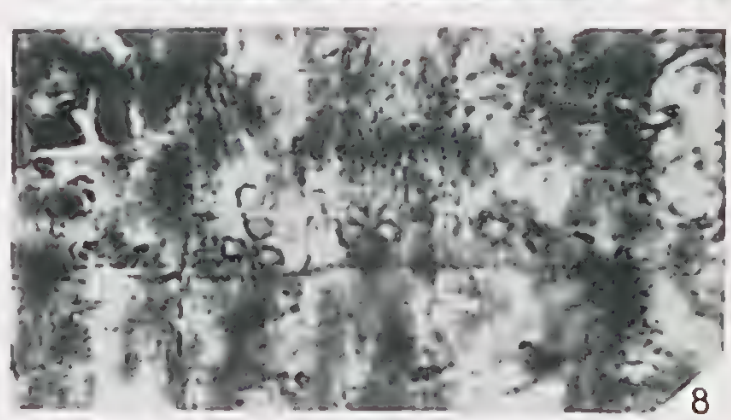
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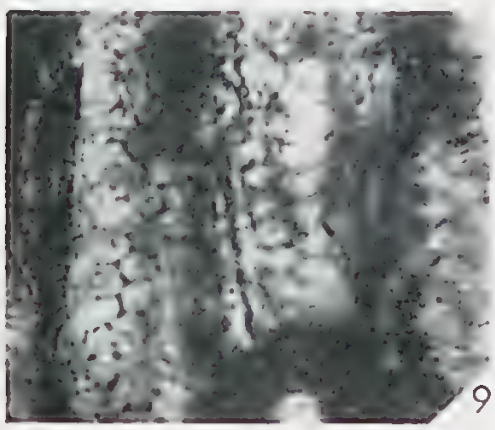
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PLATE 3

QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

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TRIASSIC MIOSPORES FROM THE TIVOLI FORMATION AND KHOLO SUB-GROUP

by
N. J. de JERSEY

BRISBANE
August, 1971

TRIASSIC MIOSPORES FROM THE TIVOLI FORMATION AND KHOLO SUB-GROUP

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Geological Survey of Queensland

SUMMARY

Miospore assemblages are recorded from 31 shale samples, from the lower part of the Ipswich Coal Measures, in south-eastern Queensland. The samples came from two drillholes which intersected the Kholo Sub-Group and the overlying Tivoli and Cooneana Formations.

From these samples, 53 miospore species are listed. One new species, *Cycadopites tivoliensis,* is described; additional information on the morphology and taxonomy of other species is recorded.

The assemblages show a general similarity to those of the Blackstone Formation, at the top of the Ipswich sequence. On the basis of this relative uniformity of the microflora, there is evidence, supported by the lithology of the sediments, for rapid deposition of the lower part of the Ipswich succession.

Compared with other Queensland microfloras, the assemblages differ significantly from those of the Moolayember Formation, of the Bowen Basin, in conformity with previous conclusions indicating a younger age for the Ipswich sediments. The additional evidence also supports previous correlation of the Tarong Beds with the Ipswich Coal Measures. Elsewhere in Australia, comparisons are closest with microfloras from the Triassic of the Leigh Creek Coal Measures of South Australia and the Brady Formation of Tasmania.

The stratigraphic distribution of species common to Queensland and European microfloras is discussed; the evidence indicates a Late Triassic, probable Karnian age for the Ipswich Coal Measures. General support to this interpretation is provided by evidence from vertebrate remains. It is concluded that the miospores have provided more precise data on the age of the sediments, than previously obtained from plant megafossils.

INTRODUCTION

In a recent paper (de Jersey, 1970b) miospore assemblages from the Blackstone Formation, the uppermost formation of the Ipswich Coal Measures, have been described. This investigation is now extended to the lower part of the Ipswich sequence, by description of miospores from the Kholo Sub-Group and the overlying Tivoli Formation. As assemblages from the Bundamba Group, which disconformably overlies the Ipswich Coal Measures, have also been described (de Jersey, 1964, 1970b, 1971), a complete record of miospore distribution in the Triassic sequence of the Ipswich area is now available.

Previous study of miospores in these lower Ipswich sediments has been confined to description of species present in the coal seams (de Jersey, 1962). As shale samples from the Blackstone Formation, recently examined, have yielded more diverse assemblages than those from the associated coals, the present investigation has, similarly, been based on shale samples from the Tivoli-Kholo sequence, to provide a comprehensive record of the species present. Description of species from these Tivoli and Kholo samples has been rendered easier by the fact that many of them have previously been recorded from the Blackstone Formation. Accordingly, in descriptive studies, attention has been concentrated on new species and on recording additional information on other species, including some not previously recorded from the Ipswich Coal Measures.

From the aspect of miospore distribution, the primary objective has been to study assemblages distributed through the complete vertical sequence of the Tivoli Formation and Kholo Sub-Group. In conjunction with the previous record of assemblages from the Blackstone Formation, this study provides a basis for recording stratigraphic distribution of species within the Ipswich Coal Measures. In addition, knowledge of these lower Ipswich assemblages enables comparison with those of the Moolayember Formation, at the top of the Triassic sequence of the Bowen Basin, to ascertain whether, like those of the Blackstone Formation, the Tivoli-Kholo assemblages are of post-Moolayember aspect. If this is the case then, as previously suggested (de Jersey and Hamilton, 1967, p. 23) there is no overlap, in time, between the Triassic sequences of the Ipswich and Bowen Basins. Finally, knowledge of assemblages from the complete sequence provides a basis for assessment of microfloral evidence on the age of the Ipswich Coal Measures, by comparison with other, accurately dated, Triassic microfloras.

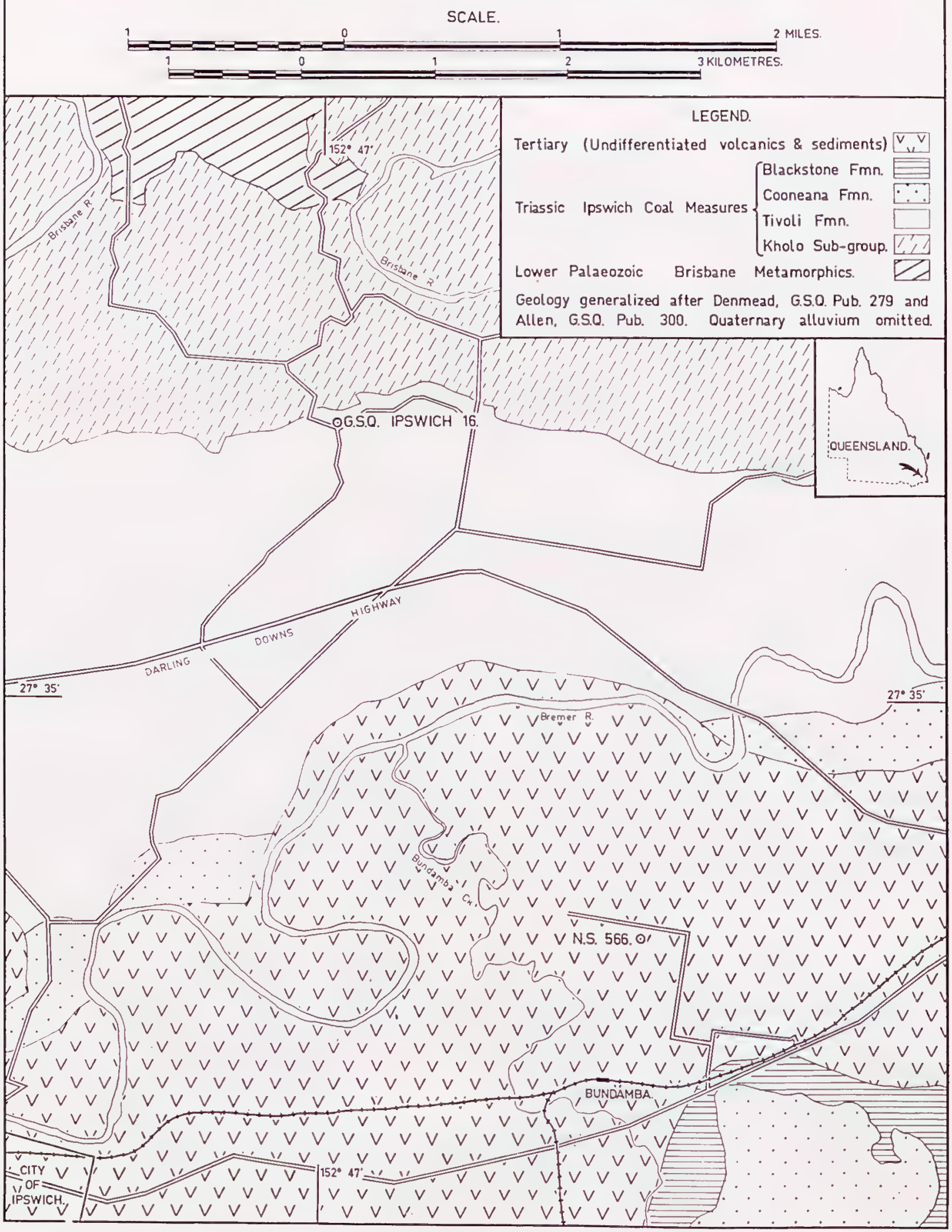
STRATIGRAPHIC DISCUSSION

The following formations, in descending stratigraphic order, comprise the Ipswich Coal Measures (Allen, Staines and Wilson, 1960, p. 252):—

	Blackstone Formation 800 ft.
	Cooneana Formation 800 ft.
	Tivoli Formation 1600 ft.
Kholo Sub-Group	Cribb Conglomerate 60 ft.
	Hector Tuff 120 ft.
	Colleges Conglomerate 800 ft.
	Mount Crosby Formation 110 + ft.
	Blackwall Breccia 30 + ft. Weir Basalt 35 + ft.

FIG. 1: LOCALITY MAP.

Showing Locations of N.S. 566 and G.S.Q. IPSWICH 16.



The Group overlies unconformably the Palaeozoic Brisbane Metamorphics and is overlain, disconformably, by the Bundamba Group.

Allen (1961, p. 1) has summarized the lithology of the Kholo Sub-Group as follows: "The Blackwall Breccia is a basal sedimentary breccia composed of detritus from the local Neranleigh-Fernvale beds. The Weir Basalt is an altered olivine basalt, apparently lying very near the base of the Sub-Group. The Mount Crosby Formation consists of polymictic cobble to pebble conglomerate, illitic-montmorillonitic shale, argillaceous litho-quartzose sandstone and rhyolitic tuff. The shale contains fossil insects and plants. The Colleges Conglomerate is a very thick polymictic pebble to cobble conglomerate, apparently deposited marginally as a fan at the foot of the D'Aguilar Block. The Hector Tuff consists of bedded acidic and sub-acidic tuff, and carbonaceous shale with thin beds of coal. The Cribb Conglomerate consists of polymictic pebble conglomerate and quartzose-feldspathic sandstone".

The lithology of the Tivoli Formation has been summarized by Allen, Staines and Wilson (1960, p. 254) as follows: "Conformably overlying the Cribb Conglomerate, the Tivoli Formation comprises more than 1600 feet of sandstone, shale and sandy shale. The lower 550 feet are principally shale and carbonaceous shale with several coal seams ("Chuwar Shales" of Denmead, 1955a). Alternating thick lenticular beds of shale and sandstone occupy the remaining 1050 feet ("Abermain Productive Beds" of Denmead, 1955a). The shales within the latter interval contain the productive coal seams of the North Ipswich mining district. These shales, which carry a proportion of calcium and iron carbonates in their composition, are generally grey in colour, but bands in the coal seams are usually brown or fawn-coloured. The sandstones of the Tivoli Formation are white and range from fine-grained to coarse-grained. The thicker beds are usually coarse, often pebbly, and contain a notable proportion of milky white fresh feldspar".

Allen and Staines (1959, p. 35) have defined the Tivoli Formation as the interval between the Cribb Conglomerate and the top of the Garden Seam. It is overlain conformably by the Cooneana Formation, a unit consisting dominantly of medium to coarse-grained pebbly sandstone.

Shale samples from the Tivoli Formation and Kholo Sub-Group were obtained from the cores of two drillholes, G.S.Q. Ipswich 16 and N.S. 566 (Ipswich). Their locations are shown on the locality map (Figure 1). Of these, G.S.Q. Ipswich 16 was completed in March, 1970, at a total depth of 1017 feet 1 inch in Brisbane Metamorphics. These basement rocks are overlain, at a depth of 970 feet, by the Blackwall Breccia, which, in turn, is succeeded, at 961 feet, by the Mount Crosby Formation. The boundary between the Mount Crosby Formation and Colleges Conglomerate is tentatively placed at 870 feet (R. J. Allen, pers. comm.). At 260 feet the Colleges Conglomerate is overlain by the Hector Tuff, which extends up to 141 feet, where it is in turn succeeded by the Cribb Conglomerate. The top of the latter unit is at 99 feet, above which the Tivoli Formation extends to the surface. The presence of basalt, of similar character to the Weir Basalt, between the depths of 748 and 751 feet, is regarded as the result of faulting, as fault breccia was cored both above and below.

The other hole, N.S. 566 (Ipswich) was drilled in 1969 and reached a total depth of 2114 feet 11 inches in the Colleges Conglomerate. This formation is overlain by the Hector Tuff at a depth of 1935 feet 11 inches, which in turn is succeeded by the Cribb Conglomerate at a depth of 1827 feet 11 inches. The base and top of the Tivoli Formation are at depths of 1779 feet and 427 feet 2 inches, respectively. The latter boundary is taken at the top of a coal section correlated with the Garden Seam; it is somewhat tentative as there is no marked change in lithology to the overlying sediments, which are provisionally assigned to the Cooneana Formation. Finally, this Triassic sequence is overlain by Tertiary sediments at a depth of 378 feet 8 inches.

The lithology of these two sections is shown diagrammatically in Figure 2, together with the correlation based on formation boundaries. It should be noted that the thicknesses of the formations in these sections are vertical thicknesses; because of the regional dip of 10°-15° of the Tivoli-Kholo sequence these intervals are slightly in excess of true stratigraphic thicknesses. Depths of the samples examined, with lists of the species recorded, are given in the Appendix of this paper. Assemblages are listed from six samples from the Mount Crosby Formation, two from the Colleges Conglomerate, four from the Hector Tuff, seventeen from the Tivoli Formation, and two from the Cooneana Formation.

PROCESSING OF SAMPLES

Conventional methods were used in laboratory treatment of the samples. The procedure was similar to that recorded in a recent paper (de Jersey, 1971, p. 3) except that the miospores were subjected to more intense oxidation (for periods of up to 15 minutes with Schulze solution). This additional oxidation was necessary because the exines were darker than, for example, those of miospores from the Blackstone Formation. Generally this slight carbonization increases progressively with increasing stratigraphic depth, the assemblages most affected being those from the Mount Crosby Formation. However the preservation of miospores in the assemblages from the Mount Crosby Formation is better than for those recorded by de Jersey and Hamilton (1965a, p. 326). The material studied in this earlier investigation came from relatively shallow depths; consequently it is likely to have been affected by slight weathering, leading to further general deterioration in the preservation of the miospores.

In the Tivoli Formation, the progressively increased darkening of the exines, with increasing stratigraphic depth, can be related to a parallel increase in the rank of the coals, noted previously (de Jersey, 1947, p. 36).

This parallelism supports the view that increasing maturity of the organic matter, with increased stratigraphic depth, has resulted from increases in the thickness of the overlying sediments.

As stated previously, figured specimens are located by the stage co-ordinates of a Carl Zeiss GFL Microscope. In addition, co-ordinates of a reference point, arbitrarily selected as the lower right hand corner of the cover glass, are recorded in the text in each case, thus assisting subsequent location of the specimens. Microslides prepared during the investigation are stored in the collection of the Palynology Section and the samples themselves are stored in the Core Library of the Geological Survey.

SYSTEMATIC DESCRIPTIONS

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reinsch *emend.* Dettmann, 1963

Subturma AZONOTRILETES Luber *emend.* Dettmann, 1963

Infraturma LAEVIGATI Bennie & Kidston *emend.* Potonié, 1956

Genus CALAMOSPORA Schopf, Wilson & Bentall, 1944

Type species:—*Calamospora hartungiana* Schopf, in Schopf, Wilson & Bentall, 1944.

Calamospora tener (Leschik) de Jersey, 1962

Distribution:—Recorded in Europe and Great Britain from the Middle and Upper Triassic and Jurassic. Queensland records: Triassic of Tivoli Formation, Blackstone Formation (de Jersey, 1962, 1970b, this paper); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Jurassic of Marburg Formation (de Jersey, 1971).

Genus DICTYOPHYLLIDITES Couper *emend.* Dettmann, 1963

Type species:—*Dictyophyllidites harrisii* Couper, 1958.

Dictyophyllidites mortoni (de Jersey) Playford & Dettman, 1965

Distribution:—Widely distributed in the Triassic and Jurassic of Eastern Australia. Queensland records: Jurassic of Walloon Coal Measures, Marburg Formation, Helidon Sandstone (de Jersey, 1959, 1963, 1971); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Kholo Sub-Group, Tivoli Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, 1971, this paper); Triassic of Tarong Beds (de Jersey, 1970c).

Genus LEIOTRILETES (Naumova) Potonié & Kremp, 1954

Type species:—*Leiotriletes sphaerotriangulus* (Loose) Potonié & Kremp, 1954.

Leiotriletes directus Balme & Hennelly, 1956

Remarks:—Spores of this simple, generalized type are very widely distributed in Lower Mesozoic assemblages from Queensland.

Genus STEREISPORITES Pflug *emend.* de Jersey, 1964

Type species:—*Stereisporites stereoides* (Potonié & Venitz) Pflug, 1953.

Stereisporites antiquasporites (Wilson & Webster) Dettmann, 1963

Plate 1, Figure 1

Figured specimen:—Slide S2709, stage co-ordinates 13.9, 100.4; diameter 30 microns. Co-ordinates of lower right hand corner of cover glass 25.9, 84.6.

Locality:—N.S. 566, 2010 feet (Colleges Conglomerate).

Distribution:—Widely distributed in Mesozoic and Tertiary sediments. Queensland records: Triassic of Mount Crosby Formation, Colleges Conglomerate, Hector Tuff, Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964; Hill, Playford and Woods, 1965; de Jersey, 1970b, this paper); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Tarong Beds (de Jersey, 1970c); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone (de Jersey, 1971).

Stereisporites perforatus Leschik, 1955

Plate 1, Figure 2

Figured specimen:—Slide S2579, stage co-ordinates 10.5, 84.9; diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.3, 84.0.

Locality:—N.S. 566, 789 feet 4 inches (Tivoli Formation).

Distribution:—Widely distributed in Mesozoic sediments. Queensland records: Triassic of Mount Crosby Formation, Tivoli Formation, Cooneana Formation, Blackstone Formation, Raceview Formation, Ripley

Road Sandstone (Hill, Playford and Woods, 1965; de Jersey, 1970b, 1971, this paper); Triassic of Tarong Beds (de Jersey, 1970c); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971).

Infraturma APICULATI Bennie & Kidston *emend.* Potonié, 1965

Subinfraturma VERRUCATI Dybová & Jachowicz, 1957

Genus CLAVATISPORITES Kedves & Simoncsics, 1964

Type species:—*Clavatisporites clavus* Kedves & Simoncsics, 1964

(Kedves & Simoncsics, 1964, p. 32, pl. 8, figs. 10-12).

Remarks:—From the diagnosis of *Clavatriletes* Herbst, 1965 (type species *Clavatriletes hammenii,* described by Herbst, 1965, p. 144, pl. 1, fig. 7, pl. 2, figs. 4, 15) it is here regarded as a junior synonym of *Clavatisporites* Kedves & Simoncsics, 1964.

Clavatisporites sp. cf. *Clavatisporites hammenii* (Herbst) de Jersey comb. nov.

Remarks:—The species described as *Clavatriletes hammenii* by Herbst (1965, p. 144, pl. 1, fig. 7; pl. 2, figs. 14, 15) is here transferred to *Clavatisporites* Kedves & Simoncsics as a new combination. From Herbst's description and figures, it appears to be distinct from the species described by those authors (Kedves & Simoncsics, 1964, pp. 32, 34). Specimens from the Moolayember Formation (de Jersey and Hamilton, 1967, pp. 6, 7), Clematis Sandstone (de Jersey, 1968, p. 5), Blackstone and Raceview Formations (de Jersey, 1970b, p. 4) and Mount Crosby, Tivoli and Cooneana Formations (this paper) are compared with this species, which was described from the Upper Triassic Los Rastros Formation, Argentina. Spores probably conspecific with the Queensland specimens have been recorded by Helby (in press) from the Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of the Sydney Basin.

Genus CONVERRUCOSISPORITES Potonié & Kremp, 1954

Type species:—*Converrucosisporites triquetrus* (Ibrahim) Potonié & Kremp, 1954.

Converrucosisporites cameroni (de Jersey) Playford & Dettmann, 1965

Distribution:—Triassic of Colleges Conglomerate, Tivoli Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b, 1971, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Tarong Beds (de Jersey, 1970c); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Wandoan Formation (de Jersey and Hamilton, 1969); Triassic and Jurassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press).

Genus CRATERISPORITES de Jersey, 1970

Type species:—*Craterisporites rotundus* de Jersey, 1970.

Craterisporites rotundus de Jersey, 1970

Plate 1, Figure 8

Figured specimen:—Slide S2640, stage co-ordinates 14.9, 101.2; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 27.6, 85.5.

Locality:—N.S. 566, 2010 feet (Colleges Conglomerate).

Remarks:—As a result of the current investigation, the range of this distinctive species is now known to extend into the Mount Crosby Formation, in the basal part of the Ipswich seuence.

Distribution:—Blackstone Formation, Aberdare Conglomerate, Raceview Formation (de Jersey, 1970b, 1971); Cooneana Formation, Tivoli Formation, Colleges Conglomerate, Mount Crosby Formation (this paper); Tarong Beds (de Jersey, 1970c).

Genus UVAESPORITES Döring, 1965 *emend.* Helby

Type species:—*Uvaesporites glomeratus* Döring, 1965.

Remarks:—Helby (in press) has proposed the following emended generic diagnosis: "Microspores, trilete with thickened equatorial exoexine which may be interpreted as a cingulum. Exine layered, often cavate. Distal and equatorial surfaces bearing massive sculptural elements which vary considerably, although gemmae usually predominate. Contact faces sharply delineated, smooth or with very much reduced sculptural elements".

This emendation has clarified interpretation of the morphology of the genus and is supported here. Thus circumscribed, *Uvaesporites* becomes a suitable repository for the species *Uvaesporites verrucosus* (de Jersey) Helby, comb. nov., recorded below.

Uvaesporites verrucosus (de Jersey, 1964) Helby, comb. nov.

Plate 1, Figures 4, 5, 6, 7

Selected synonymy

1964 *Discisporites verrucosus* de Jersey, p. 12, pl. 2, figs. 13, 15, 16.

1969 *Cadargasporites verrucosus* Reiser & Williams, p. 6, pl. 2, figs. 10-13, pl. 3, figs. 1, 2.

1970 *Camerosporites verrucosus* (de Jersey) de Jersey; de Jersey, 1970b, p. 18, pl. 6, figs. 4-7.

1971 *Camerosporites clarkei* (de Jersey) de Jersey; de Jersey, 1971, p. 19.

Figured specimen (*Plate* 1, *Figure* 4):—Slide S2581, stage co-ordinates 11.9, 86.8; diameter 28 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 84.5.

Locality:—N.S. 566, 899 feet 7 inches (Tivoli Formation).

Figured specimen (*Plate* 1, *Figure* 5)—Slide S2577, stage co-ordinates 18.0, 97.0; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 26.1, 85.8.

Locality:—N.S. 566, 789 feet 4 inches (Tivoli Formation).

Figured specimen (*Plate* 1, *Figures* 6, 7—*distal. proximal foci*):—Slide S2571, stage co-ordinates 10.2, 88.7; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 27.2, 86.1.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—Considerable difficulty has been experienced in interpretation of the morphology of Queensland specimens of this species. On the basis of well preserved material from the Sydney Basin, Helby (in press) has demonstrated that the species is appropriately assigned to *Uvaesporites* Döring, as emended by himself. Specimens examined by the writer, from the Triassic of Queensland, rarely exhibit distinct trilete laesurae, presumably as a result of poor preservation of the thin, delicate proximal exine. Consequently the species was interpreted as a pollen grain with a thin distal exine and assigned to *Camerosporites* Leschik *emend.* Clarke, 1965 (de Jersey, 1970b, p. 18; 1971, p. 19). However Helby (in press) has demonstrated the trilete character of specimens otherwise similar to those from the Queensland Triassic assemblages, thus supporting assignment to the trilete spore genus *Uvaesporites.*

Study of assemblages from the Tivoli Formation and Kholo Sub-Group has again illustrated the poor preservation of Queensland Triassic material of this species, as specimens with the proximal exine and laesurae well preserved are relatively rare. However three specimens have been observed with distinct evidence of trilete laesurae (Plate 1, Figures 4-7 of this paper); they thus provide support to Helby's assignment of the species *Uvaesporites.*

Specimens described by Reiser and Williams (1969, p. 6; pl. 2, figs. 10-13; pl. 3, figs. 1, 2) from the Jurassic of the Surat Basin are better preserved than the Queensland Triassic material. They conform closely to Helby's interpretation of *U. verrucosus* and are accordingly placed in synonymy with this species. These Jurassic spores, and those recorded by Helby from the Sydney Basin, provide evidence of the two-layered, occasionally cavate condition of the exine. A specimen from the Tivoli Formation, with the intexine clearly evident, is figured in Plate 1, Figure 5 of this paper. In some cases the cavity between intexine and exoexine may closely simulate a ring-tenuitas (rimula); the original assignment of the species to *Discisporites* (de Jersey, 1964, p. 12) was made on the basis of such specimens. A specimen illustrating this condition is figured in Plate 1, Figures 6 and 7 of this paper.

Distribution:—Triassic of Mount Crosby Formation, Colleges Conglomerate, Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, 1971, this paper); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971).

Subinfraturma NODATI Dybová & Jachowicz, 1967

Genus ACANTHOTRILETES Naumova *emend.* Potonié & Kremp, 1954

Type species:—*Acanthotriletes ciliatus* (Knox) Potonié & Kremp, 1954.

Acanthotriletes bradiensis Playford, 1965

Plate 2, Figure 6

Figured specimen:—Slide S2571, stage co-ordinates 15.2, 94.1; diameter 44 microns (excluding projections). Co-ordinates of lower right-hand corner of cover glass 27.2, 86.1.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Distribution:—Triassic of Brady Formation and "Feldspathic Sandstone" of Tasmania (Playford, 1965); Triassic of Blackstone Formation (Hill, Playford and Woods, 1965); Tivoli Formation (this paper).

Genus ANAPICULATISPORITES Potonié & Kremp, 1954

Type species:—*Anapiculatisporites isselburgensis* Potonié & Kremp, 1954.

Anapiculatisporites pristidentatus Reiser & Williams, 1969

Plate 1, Figure 3

Figured specimen:—Slide S2574, stage co-ordinates 13.0, 87.7. Diameter (including projections) 46 microns. Co-ordinates of lower right hand corner of cover glass 27.1, 84.3.

Locality:—N.S. 566, 678 feet (Tivoli Formation).

Distribution:—Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971); Triassic of Colleges Conglomerate, Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, 1971, this paper); Triassic of Tarong Beds (de Jersey, 1970c).

Genus APICULATISPORIS Potonié & Kremp, 1956

Type species:—*Apiculatisporis aculeatus* (Ibrahim) Potonié, 1956.

Apiculatisporis globosus (Leschik) Playford & Dettmann, 1965

Plate 1, Figure 9

Figured specimen:—Slide S2570, stage co-ordinates 10.4, 100.2; diameter 66 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.0.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—A characteristic feature of Ipswich specimens assigned to this species, and also of those described from Leigh Creek by Playford and Dettmann (1965, p. 137) and from Tasmania by Playford (1965, p. 183) is the presence of laesurae with distinctly thickened lips. In this respect specimens from Triassic sediments in these areas conform to the original diagnosis of Leschik (1955, p. 18, pl. 2, fig. 8) and differ from spores from the Clematis Sandstone described as *A. clematisi* (de Jersey, 1968, pp. 6, 7). In addition the sculptural elements of the former, although they exhibit some variation have a general tendency to be more elongate (spinose rather than conate) than those of the Clematis species.

Distribution:—Middle Keuper of Switzerland (Leschik, 1955), Liassic of Sweden (Nilsson, 1958); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tivoli Formation, Cooneana Formation, Blackstone Formation, Raceview Formation, Ripley Road Sandstone (Hill, Playford and Woods, 1965; de Jersey, 1970b, 1971, this paper); Jurassic of Helidon Sandstone (de Jersey, 1971).

Genus OSMUNDACIDITES Couper, 1953

Type species:—*Osmundacidites wellmanii* Couper, 1953.

Remarks:—Apart from spores assigned to *Osmundacidites wellmanii,* recorded below and in the assemblage lists, specific identification of specimens assigned to *Osmundacidites* has not been attempted. Many of the specimens of *Osmundacidites,* observed in the present study, are poorly preserved; moreover it seems unlikely that any attempted specific differentiation would have stratigraphic application, within the section studied.

Osmundacidites wellmanii Couper, 1953

Distribution:—Very widespread in Mesozoic sediments. To the Queensland records of the species reported by the writer (de Jersey, 1970b, p. 6; 1971, p. 6) can now be added occurrences in the Colleges Conglomerate and Tivoli Formation. Helby (in press) has recently reported the species as widely distributed throughout the Triassic of the Sydney Basin.

Genus PUSTULATISPORITES Potonié & Kremp, 1954

Type species:—*Pustulatisporites pustulatus* Potonié & Kremp, 1954.

Pustulatisporites blackstonensis de Jersey, 1970

Plate 1, Figure 10

Figured specimen:—Slide S2555, stage co-ordinates 12.0, 95.8; diameter 49 microns. Co-ordinates of lower right hand corner of cover glass 26.1, 84.4.

Locality:—N.S. 566, 395 feet 8 inches (Cooneana Formation)

Distribution:—Triassic of Mount Crosby Formation, Tivoli Formation, Cooneana Formation (this paper); Triassic of Blackstone Formation, Aberdare Conglomerate, Raceview Formation (de Jersey, 1970b, 1971); Triassic of Tarong Beds (de Jersey, 1970c).

Subinfraturma BACULATI Dybová & Jachowicz, 1957

Genus BACULATISPORITES Thomson & Pflug, 1953

Type species:—*Baculatisporites primarius* (Wolff) Thomson & Pflug, 1953.

Baculatisporites comaumensis (Cookson) Potonié, 1956

Plate 2, Figure 2

Figured specimen:—Slide S2599, stage co-ordinates 23.0, 97.4; diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 85.1.

Locality:—N.S.566, 1487 feet 1 inch (Tivoli Formation).

Distribution:—Widespread in Australian Mesozoic sediments; has been reported in Europe from the Upper Muschelkalk onwards (e.g., Klaus, 1960; Schulz, 1966). Queensland records: Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971); Cretaceous of Wallumbilla Formation (de Jersey and Paten, 1964); Triassic of Ipswich Coal Measures, Aberdare Conglomerate, Raceview Formation (de Jersey, 1970b, this paper); Jurassic of Razorback Beds (Playford and Cornelius, 1967).

Genus CADARGASPORITES de Jersey & Paten *emend.* Reiser & Williams, 1969

Type species:—*Cadargasporites baculatus* de Jersey & Paten *emend.* Reiser & Williams, 1969.

Cadargasporites baculatus de Jersey & Paten *emend.* Reiser & Williams, 1969

Plate 2, Figures 1 and 5

Figured specimen (*Plate* 2, *Figures* 1, 5—*proximal, distal foci*): Slide S2568, stage co-ordinates 14.8, 92.8; diameter 81 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 82.9.

Locality:—N.S. 566, 579 feet 9 inches (Tivoli Formation).

Remarks:—The specimen figured is a typical example of this species. As discussed elsewhere in this paper, the presence of *C. baculatus* is one of the features by which the Ipswich assemblages can be distinguished from those of the Moolayember Formation.

Distribution:—Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969; Jurassic of Helidon Sandstone, Marburg Formation of Moreton Basin (de Jersey, 1971); Triassic of Tivoli Formation, Blackstone Formation, Raceview Formation, Ripley Road Sandstone (de Jersey, 1970b, 1971, this paper).

Genus CONBACULATISPORITES Klaus, 1960

Type species:—*Conbaculatisporites mesozoicus* Klaus, 1960.

Conbaculatisporites sp. cf. *C. mesozoicus* Klaus, 1960

Plate 2, Figure 4

Figured specimen:—Slide S2569, stage co-ordinates 19.9, 85.5; diameter 46 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.8.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—The specimen figured is representative of spores from the Tivoli-Kholo assemblages, which resemble *C. mesozoicus* in size, shape of the amb, laesurate characters and presence of baculate sculpture, but lack the inter-radial reduction of the sculptural elements regarded by Klaus (1960, p. 126) as a diagnostic feature of the species. Accordingly the Queensland spores are not formally identified with *C. mesozoicus*. Their size range (overall diameter of amb, based on 12 measured specimens) is from 30 to 46 microns.

Distribution of C. mesozoicus:—Karnian of Austria (Klaus, 1960); Lower, Middle and Upper Keuper and Hettangian of East Germany (Schulz, 1966).

Distribution of C. cf. mesozoicus:—Tivoli Formation, Kholo Sub-Group (this paper).

Genus NEORAISTRICKIA Potonié, 1956

Type species:— *Neoraistrickia truncata* (Cookson) Potonié 1956.

Neoraistrickia taylorii Playford & Dettmann, 1965

Distribution:—Triassic of Tivoli Formation, Blackstone Formation, Raceview Formation (Hill, Playford and Woods, 1965; de Jersey, 1970b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Wandoan Formation (de Jersey and Hamilton, 1969); Triassic of Tarong Beds (de Jersey, 1970c); Triassic and Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Late Triassic of Tasmania (Playford 1965); Triassic of Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of New South Wales (Helby, in press); Jurassic of Precipice Sandstone, Evergreen Formation and lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971).

Infraturma MURORNATI Potonié & Kremp, 1954

Genus DUPLEXISPORITES Deák *emend.* Playford & Dettmann, 1965

Type species:—*Duplexisporites generalis* Deák, 1962.

Duplexisporites problematicus (Couper) Playford & Dettmann, 1965

Plate 2, Figure 3

Figured specimen:—Slide S2549, stage co-ordinates 15.4, 90.5; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.7.

Locality:—N.S. 566, 385 feet 5 inches (Cooneana Formation)

Remarks:—The morphology and synonymy of this species have been recently discussed (de Jersey, 1970b, p. 8; Helby, in press). It is a persistent, usually abundant component of assemblages from the Tivoli Formation and Kholo Sub-Group.

Distribution:—Widely distributed in Triassic and Jurassic microfloras. Queensland records: Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Wandoan Formation (de Jersey and Hamilton, 1969); Triassic of Kholo Sub-Group, Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey 1964; Hill, Playford and Woods, 1965; de Jersey, 1970b, this paper); Triassic of Tarong Beds (de Jersey 1970c); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971).

Turma ZONALES Bennie & Kidston *emend.* Potonié, 1956

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI Potonié & Klaus *emend.* Dettmann, 1963

Genus ANNULISPORA de Jersey, 1959

Type species:—*Annulispora folliculosa* (Rogalska) de Jersey, 1959.

Annulispora folliculosa (Rogalska) de Jersey, 1959

Plate 3, Figure 1

Figured specimen:—Slide S2698, stage co-ordinates 15.9, 90.6; diameter 26 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 85.5.

Locality:—G.S.Q. Ipswich 16, 942 feet 5 inches (Mount Crosby Formation).

Remarks:—Two specimens have recently been recorded by Helby (in press) from the Bringelly Shale of the Wianamatta Group (Sydney Basin). They have been designated as *Annulispora* sp. cf. *A. folliculosa;* the specimen figured appears to have a broader cingulum than typical specimens of *A. folliculosa.*

Distribution:—Triassic of Mount Crosby Formation, Colleges Conglomerate, Tivoli Formation, Cooneana Formation, Blackstone Formation. Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b, this paper); Triassic of Tarong Beds (de Jersey, 1970c); Upper Triassic of Tasmania (Playford, 1965); Liassic of Poland (Rogalska, 1954); Jurassic of Helidon Sandstone, Marburg Formation, Walloon Coal Measures (de Jersey, 1959, 1963, 1971); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967).

Annulispora microannulata de Jersey, 1962

Plate 3, Figure 2

Figured specimen:—Slide S2568, stage co-ordinates 21.6, 92.3; diameter 31 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 82.9.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Distribution:—Triassic of Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Tarong Beds (de Jersey, 1970c); Jurassic of Precipice Sandstone, Evergreen Formation, Hutton Sandstone, Walloon Coal Measures of Surat Basin (de Jersey and Paten, 1964; Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1963, 1971).

Genus DENSOSPORITES Berry *emend.* Butterworth, Jansonius, Smith & Staplin, 1964

Type species:—*Densosporites covensis* Berry, 1937.

Densosporites raceviewensis de Jersey, 1971

Remarks:—This species is a rare component of the Tivoli and Kholo assemblages.

Distribution:—Raceview Formation (de Jersey, 1970b, 1971); Tivoli Formation, Mount Crosby Formation (this paper).

Genus LYCOSPORA (Schopf, Wilson & Bentall) Potonié & Kremp, 1954

Type species:—*Lycospora micropapillata* (Wilson & Coe) Schopf, Wilson & Bentall, 1944.

Lycospora pallida (de Jersey, 1962) de Jersey, comb. nov.

Plate 3, Figures 3, 4, 5, 6

1962 *Cingulatisporites pallidus* de Jersey, p. 6, pl. 2, figs. 4, 5

Description:—Trilete, cingulate, two-layered miospores. Amb convexly sub-triangular to sub-circular. Diameter (based on 27 measured specimens) 33 to 50 microns. Laesurae, straight or slightly sinuous, lips distinct and slightly raised, extend to inner edge of cingulum. Cingulum about 2 to 7 microns wide, broader in inter-radial regions, thickened at base for a width of about 1.5 microns; outer portion membranous, may have sculpture of fine coni (basal diameter 0.5 to 1 micron) near equator. Distal exoexine with varied sculpture, comprising rugulae (basal width 1.5 to 2 microns, height about 1 micron) with variable proportions of coni, spinae and verrucae. Conate, spinose and verrucose elements about 1.5 to 2 microns high, 1 to 1.5 microns in basal diameter. Rugulae may join to form an imperfect recticulum. Proximal exoexine smooth or scabrate. Intexine smooth, thin (less than 1 micron). Intexine inconspicuous (closely attached to exoexine) to distinctly separated (cavate).

Figured specimen (*Plate* 3, *Figures* 3, 6—*proximal, distal foci*: Slide S2570, stage co-ordinates 15.0 94.2; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.0.

Locality:—N.S. 566, 789 feet 4 inches (Tivoli Formation).

Figured specimen (*Plate* 3, *Figures* 4, 5—*proximal, distal foci*:—Slide S2578, stage co-ordinates 18.6, 91.0; diameter 35 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.6.

Locality:—N.S. 566, 789 feet 4 inches (Tivoli Formation).

Remarks:—Additional material studied in the present investigation has provided further evidence on the range of variation in sculpture in this species and has demonstrated the presence of an intexine. These features are indicated by the specimens figured; that illustrated in Plate 3, Figures 3 and 6 has a distal sculpture of rugulae and discrete elements, including coni, spinae and verrucae while the specimen figured in Plate 3, Figures 4 and 5 illustrates the development of an imperfect reticulum, by joining of the distal rugulae. Continuous gradation exists in the specimens studied, indicating that the original type material (de Jersey, 1962, p. 6) represents that proportion of the specific population in which a vague, imperfect reticulum is developed.

The original generic diagnosis of *Cingulatisporites* (of Thomson, in Thomson and Pflug, 1953) was very broad and would encompass several currently recognized genera. Consequently, since *C. pallidus* was described in 1962, there has been a trend to transfer species assigned to *Cingulatisporites* to other, more narrowly defined genera. If *Cingulatisporites* is restricted around its laevigate type species, the distal sculpture of these Queensland spores would necessitate their exclusion from the genus. Accordingly *C. pallidus,* is here transferred as a new combination to *Lycospora* (Schopf, Wilson & Bentall) Potonié & Kremp, 1954. Although not a typical member of *Lycospora,* it appears closest to it in overall morphology, when available established genera are considered. The principal differences from typical species of *Lycospora* are (1) the presence of an intexine and development of the cavate condition in some specimens, and (2) the presence of rugulate sculptural elements, which may join to form an imperfect reticulum.

Regarding the former aspect, Smith and Butterworth (1967, p. 245) state "This genus is tentatively included within the Cingulicavati because of its close lithological similarity to *Densosporites* and *Cingulizonates* and because the apical papillae recognizable in some specimens suggest the presence of an intexine". Accordingly, the presence of an intexine in this species is not regarded as a significant obstacle to its assignment to *Lycospora.* The development of the cavate condition is not considered to be significant, from the generic aspect, as there appears to be continuous gradation from such specimens to those in which the layers are closely attached.

Concerning the latter aspect (presence of rugulate sculptural elements associated with coni, spinae and verrucae) a species which is comparable to some extent is *Lycospora noctuina* Butterworth & Williams, 1958, in which rugulate sculptural elements are present as well as grana and verrucae (Smith and Butterworth, 1967, p. 248). A precedent thus exists for including species with rugulate sculptural elements in *Lycospora*; the development of a vague reticulum in some specimens is considered to be an extreme case, and not of sufficient diagnostic importance to justify the exclusion of this rather variable species from the genus.

Lycospora pallida (de Jersey) comb. nov. differs, as indicated, from previously described species of *Lycospora,* in having a distinct intexine and in the nature of the distal sculpture. Other distinctive features are inter-radial broadening of the cingulum and the fragile, membranous nature of its outer (equatorial) region. No close comparison can be made with other species, previously described from the Mesozoic of Australia.

Distribution:—Triassic of Tivoli Formation (de Jersey, 1962, this paper), Triassic of Tingalpa Formation, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group (Helby, in press); Tarong Beds (de Jersey, 1970c); (Re-examination of a specimen recorded from the Tarong Beds (de Jersey, 1970c, p. 309) as "cf. *Cingulatisporites pallidus*" indicates that it can be identified with *L. pallida*).

Genus POLYCINGULATISPORITES Simoncsics & Kedves *emend.* Playford & Dettman, 1965

Type species:—*Polycingulatisporites circulus* Simoncsics & Kedves, 1961.

Polycingulatisporites densatus (de Jersey) Playford & Dettmann, 1965

Distribution:—Jurassic of Walloon Coal Measures, Rosewood Coalfield (de Jersey, 1959); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971); Jurassic of Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Razorback Beds (Playford and Cornelius, 1967); Triassic of Mount Crosby Formation (de Jersey and Hamilton, 1965a); Triassic of Tivoli Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, 1971, this paper); Triassic and Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965).

Genus REWANISPORA de Jersey, 1970

Type species:—*Rewanispora foveolata* de Jersey, 1970.

Rewanispora foveolata de Jersey, 1970

Plate 3, Figures 7 and 8

Figured specimen (*Plate* 3, *Figures* 7, 8—*proximal, distal foci*):—Slide S2557, stage co-ordinates 22.2, 102.4; diameter 38 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 84.5.

Locality:—N.S. 566, 523 feet 1 inch (Tivoli Formation).

Remarks:—Spores from the Cooneana Formation and Kholo Sub-Group, of which the figured specimen is representative, are indistinguishable in all significant diagnostic features, from *R. foveolata* (de Jersey, 1970a, p. 9). The discovery of this Rewan species in the Ipswich Coal Measures is of interest, in that it

appreciably extends its stratigraphic range. Precedent exists, however, in the Australian Triassic for the occurrence of long-ranged, distinctive species, a notable example being *Guthoerlisporites cancellosus* Playford & Dettmann, 1965.

The species *Semiretisporis antiquus,* recorded from the Bundamba Group and Blackstone Formation(de Jersey, 1970b, p. 12), has distal foveolate sculpture similar to that of *R. foveolata,* but differs in having a marked development of larger foveolae in the equatorial region. A flange or zona-like structure is present, rather than a dense cingulum as in *R. foveolata.*

Although the possibility exists that forms intermediate between the two species may be found, it is considered preferable to treat them as distinct, on present evidence. There is some stratigraphic evidence against uniting the species, as in assemblages from the Bundamba Group, in some of which *S. antiquus* is quite common (de Jersey, 1970b, p. 40) no cingulate spores of the *R. foveolata* type have been recorded. It is thus suggested that the parent plant of spores of the *S. antiquus* type may have been derived, in the Late Triassic, from that producing *R. foveolata,* as development of larger foveolae in the cingulum of the latter would convert it, by extreme dissection, into a flange-like structure.

Distribution:—Triassic of Rewan Formation (de Jersey, 1970a); Triassic of Mount Crosby Formation, Hector Tuff, Tivoli Formation, Cooneana Formation (this paper); Triassic of Narrabeen Group (Helby, in press).

Subturma PERINOTRILITES Erdtman, 1947

Genus SEMIRETISPORIS Reinhardt, 1962

Type species:— *Semiretisporis gothae* Reinhardt, 1962.

Semiretisporis denmeadi (de Jersey) de Jersey, 1970

Remarks:—The morphology and taxonomy of this species have been recently discussed (de Jersey, 1970b, pp. 12, 13). Because of the arched character of the distal exine, the characteristic reticulum imperfectum is difficult to photograph in overall focus. It is, however, evident in a specimen from the Blackstone Formation (de Jersey, 1970b, pl. 4, fig. 8) and is also well shown in a Tasmanian specimen figured by Playford (1965, pl. 9, fig. 4).

Distribution:—Triassic of Tivoli, Cooneana and Blackstone Formations of Ipswich Coal Measures (de Jersey, 1962; Hill, Playford and Woods, 1955; de Jersey, 1970b, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965).

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma SCULPTATOMONOLETI Dybová & Jachowicz, 1957

Genus ARATRISPORITES Leschik *emend.* Playford & Dettmann, 1965

Type species:—*Aratrisporites parvispinosus* Leschik *emend.* Playford, 1965.

Remarks:—The writer (de Jersey, 1962, pp. 14, 15; pl. 5, fig. 12; pl. 6, fig. 1) described the genus *Tenuisaccites* from coal of the Four Feet seam, in the Blackstone Formation. Distinctive features of the taxon included the presence of two layers of exine, the inner moderately thick and of ovate outline and the outer thin, fragile and lacking coarse sculptural elements. The specimens appeared to be alete. Recent re-examination of these specimens with improved optical equipment has revealed the presence of faint monolete laesurae in some of them, also that the coarse sculptural elements, thought to be on the inner layer, are actually confined to the distal polar region of the thin outer layer. This re-interpretation of the morphology of these specimens indicate that they conform to the diagnosis of *Aratrisporites* Leschik *emend.* Playford & Dettmann, 1965. Accordingly *Tenuisaccites* is regarded as a synonym of *Aratrisporites and Tenuisaccites fragilis* de Jersey, 1962 (de Jersey, 1962, p. 15, p. 5, fig. 2; pl. 6, fig. 1) is transferred to that genus as a new combination.

Specimens of this type have not been observed in the assemblages recorded in this paper. They have some features in common with *Aratrisporites banksi* Playford, 1965, notably their large size and relatively small inner layer (relative to the overall dimensions). However, they lack the prominent elevated lips and distinctive sculpture of that species. As it is not clear whether these differences are significant, from the aspect of specific differentiation, or whether they are due to poor preservation or over-maceration of the specimens derived from the coal samples, final assessment of the relationship between *A. banksi* Playford and *A. fragilis* (de Jersey) comb. nov. must await study of further specimens of the latter species.

Aratrisporites banksi Playford, 1965

Remarks:—Specimens of this species, from the Ipswich Coal Measures, have been figured by Hill, Playford and Woods (1965, pl. 11, fig. 1) and de Jersey (1970b, pl. 5, fig. 4).

Distribution:—Triassic of Tiers Formation, Tasmania (Playford, 1965); Triassic of Blackstone Formation (Hill, Playford and Woods, 1965; de Jersey, 1970b); Cooneana Formation, Tivoli Formation (this paper).

Aratrisporites flexibilis Playford & Dettmann, 1965

Plate 3, Figures 10 and 11; Plate 4, Figure 4

Figured specimen (*Plate* 3, *Figures* 10, 11-*proximal, distal-equatorial foci*):—Slide S2569, stage co-ordinates 9.8, 102.2; overall dimensions 66 x 56 microns (excluding projections), inner layer 53 x 46 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.8.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Figured specimen (*Plate* 4, *Figure* 4):—Slide S2568, stage co-ordinates 12.7, 95.9; overall dimensions 54 x 43 microns (excluding projections). Co-ordinates of lower right hand corner of cover glass 27.0, 82.9.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—Distinctive features of this species are the prominent lips, the thin, inconspicuous inner layer and the elongate (baculate or saetose) nature of the sparsely distributed projections. These features are illustrated by the specimens figured; the thin inner layer, which is difficult to detect in some of the Queensland specimens, is evident in Plate 3, Figure 10. Identification of the specimens figured with *A. flexibilis* is based on comparison with the type material and is supported by Dr. Playford (pers. comm.).

Aratrisporites flexibilis differs from *A. parvispinosus,* recorded below, in having a thicker sculptine and baculate or saetose, rather than spinose projections. Species which show some similarity in the shape of their sculptural elements are *A. fischeri* (Klaus) Playford & Dettmann, 1965, *A. palettae* (Klaus) Playford & Dettmann, 1965, and *A. fimbriatus* (Klaus) Playford & Dettmann, 1965. As stated by Playford and Dettmann (1965, p. 154) *A. flexibilis* can be distinguished from these species by its larger sculptural elements, thinner inner layer and smaller cavity between the two sclerine layers.

Distribution:—Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Blackstone Formation (Hill, Playford and Woods, 1965; de Jersey, 1970b); Cooneana Formation, Tivoli Formation (this paper); Tarong Beds (de Jersey, 1970c).

Aratrisporites sp. cf. *A. granulatus* (Klaus) Playford & Dettmann, 1965

Plate 3, Figure 9

Figured specimen:—Slide S2578, stage co-ordinates 15.8, 94.6; dimensions 31 x 28 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.6.

Locality:—N.S. 566, 789 feet 4 inches (Tivoli Formation).

Remarks:—Three specimens have been recorded which resemble *Aratrisporites granulatus,* described by Klaus (1960, p. 143) from the Karnian of Austria, in overall shape, dimensions and in the general appearance of the sculptine. However, because of the relatively poor preservation of the sculptural elements, it is not clear whether they are dominantly granulate, as in *A. granulatus*, or whether the bases of broken spinose or conate elements give the appearance of grana.

Distribution:—Colleges Conglomerate, Tivoli Formation (this paper).

Aratrisporites sp. cf. *A. paenulatus* Playford & Dettmann, 1965

Plate 4, Figure 3

Figured specimen:—Slide S2511, stage co-ordinates 8.9, 89.4; overall dimensions 54 x 40 microns; inner layer 43 x 31 microns. Co-ordinates of lower right hand corner of cover glass 27.2, 86.1.

Locality:—N.S. 566, 579 feet 9 inches (Tivoli Formation).

Remarks:—The specimen figured conforms to the description of *A. paenulatus* by Playford and Dettmann (1965, pl. 154) in the nature and spacing of the sculptural elements and in its shape and general construction. However, it is appreciably larger than the specimens recorded by those authors, who quoted a range in overall length (based on fourteen measured specimens) from 35 to 43 microns. As this is the only specimen of this type observed in the material studied, it is compared, rather than identified, with *A. paenulatus.*

Distribution of A. paenulatus:—Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965).

Aratrisporites parvispinosus Leschik *emend.* Playford, 1965

Plate 4, Figure 7

Figured specimen:—Slide S2549, stage co-ordinates 8.6, 90.8; dimensions: overall length 86 microns, inner layer 63 x 41 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.7.

Locality:—N.S. 566, 385 feet 5 inches (Cooneana Formation).

Remarks:—The specimens recorded are identified with *A. parvispinosus* on the basis of the description and figures of Leschik (1955, p. 38; pl. 5, figs. 2, 4) and Playford (1965, p. 194; pl. 10, figs. 1, 2). The example figured illustrates the distinctive spinose ornament of the thin, readily folded sculptine. In this specimen the spines are mostly about 3 microns in height, 2 microns in basal diameter and about 3 microns apart at the equator.

A. parvispinosus can be distinguished from other apiculate species of *Aratrisporites* by its thin, readily folded sculptine and by the nature of the sculptural elements. *A. flexibilis*, also recorded from the Ipswich Coal Measures, has a thicker, more rigid sculptine, a thinner, less distinct inner layer and projections which are more elongate in relation to their basal diameters. The spores of *A. paenulatus* Playford & Dettmann, 1965 are significantly smaller and have somewhat smaller, more sparsely distributed projections. In *A. goulburniensis* Helby, 1967 the sculptine is relatively thicker and the sculptural elements are more massive.

Among European species, *A. fimbriatus* (Klaus) Playford & Dettmann, 1965 differs in having hair-like

sculptural elements and a larger cavity between the two sclerine layers, while in *A. paraspinosus* Klaus, 1960 the projections are characterized by rounded extremities. *A. fischeri* (Klaus) Playford & Dettmann, 1965 and *A. palettae* (Klaus) Playford & Dettmann, 1965 are larger species which have a thicker, more rigid sculptine and hair-like projections. *Zonomonoletes tschalyschevii* Varyukhina, 1962 differs in having rounded more isodiametric projections.

In Queensland, spores definitely identifiable with Leschik's species appear to be confined to the Ipswich Coal Measures, and absent from the older Triassic sediments of the Bowen Basin. Specimens described by the writer (de Jersey, 1970a, p. 10) from the Rewan Formation, although they have rather similar sculptural elements, differ in having an inner layer which is less distinct and smaller, relative to the overall diameter of the amb, and have accordingly been recorded as *Aratrisporites* sp. cf. *A. parvispinosus*.

Distribution:—Middle Keuper of Switzerland (Leschik, 1955); Upper Triassic of Tasmania (Playford, 1965); Blackstone Formation (Hill, Playford and Woods, 1965); Cooneana Formation, Tivoli Formation (this paper). The species has recently been recorded from the Anisian of Rumania by Antonescu (1970, p. 23). Unfortunately the quality of the accompanying illustration (pl. 10, fig. 8) does not permit close comparison with the type material of the species.

Genus POLYPODIISPORITES Potonié & Gelletich ex Potonié, 1956

Type species:—*Polypodiisporites favus* (Potonié) Potonié & Gelletich, 1933.

Polypodiisporites ipsviciensis (de Jersey) Playford & Dettmann, 1965

Distribution:—Triassic of Mount Crosby Formation, Colleges Conglomerate, Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b, 1971, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey 1968, 1970a); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Wollar Sandstone, New South Wales (Helby, 1967); Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press); Triassic of Cacheuta Formation, Argentina (Jain, 1968).

Genus PUNCTATOSPORITES Ibrahim, 1933

Type species:—*Punctatosporites minutus* Ibrahim, 1933.

Punctatosporites walkomi de Jersey, 1962

Distribution:—Triassic of Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b, 1971, this paper); Triassic of Moorooka and Tingalpa Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Triassic of Tasmania (Playford, 1965); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone (Reiser and Williams, 1969); Jurassic of Helidon Sandstone (de Jersey, 1971).

Genus TUBERCULATOSPORITES Imgrund, 1952

Type species:—*Tuberculatosporites anicystoides* Imgrund, 1952.

Tuberculatosporites aberdarensis de Jersey, 1964

Distribution:—Triassic of Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Ripley Road Sandstone (de Jersey, 1964, 1970b, this paper); Triassic of Tarong Beds (de Jersey, 1970c); Narrabeen Group, Hawkesbury Sandstone, Wianamatta Group of New South Wales (Helby, in press).

Anteturma	POLLENITES Potonié, 1931
Turma	SACCITES Erdtman, 1947
Subturma	MONOSACCITES Chitaley *emend.* Potonié & Kremp, 1954
Infraturma	TRILETESACCITI Leschik, 1955
Subinfraturma	INTRORNATI Butterworth & Williams, 1958
Genus	GUTHOERLISPORITES Bharadwaj, 1954

Type species:—*Guthoerlisporites magnificus* Bhardwaj, 1954.

Guthoerlisporites cancellosus Playford & Dettmann, 1965

Remarks:—The writer supports Playford and Dettmann (1965, pp. 146, 147) in assigning this species to *Guthoerlisporites* Bharadwaj, 1954 rather than to *Endosporites* Wilson and Coe, 1940. The fine regular reticulum of the outer layer in species of *Guthoerlisporites* is regarded as a feature by which they can be distinguished from *Endosporites*.

Distribution:—Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Triassic of Tasmania (Playford, 1965); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Mount Crosby Formation, Tivoli Formation, Cooneana Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation (Hill, Playford and Woods, 1965; de Jersey,

1970b, this paper); Triassic of Tarong Beds (de Jersey, 1970c); Narrabeen Group, Hawkesbury Sandstone, Wianamatta Group of Sydney Basin (Helby, in press).

Subinfraturma EXTRORNATI Butterworth & Williams, 1958

Genus GRANDISPORA Hoffmeister, Staplin & Malloy, 1955

Type species:—*Grandispora spinosa* Hoffmeister, Staplin & Malloy, 1955.

Grandispora sp. A

Plate 4, Figure 5

Description:—Trilete, cavate miospores. Amb convexly sub-triangular to sub-circular. Diameter (based on 10 measured specimens) 23 to 43 microns. Laesurae extend to margin of intexine, straight or slightly sinuous, lips may be slightly thickened. Exoexine smooth proximally, sculptured distally and equatorially. Sculpture dominantly of coni, with some bacula and spinae; elements 0.5 to 1.5 microns in height, about 1 to 1.5 microns apart. Intexine smooth, thin, diameter in polar view 18 to 30 microns, outline conformable with amb.

Figured specimen:—Slide S2549, stage co-ordinates 20.9, 96.7; diameter 43 microns. Co-ordinates of lower right hand corner of cover glass 26.9, 82.7.

Locality:—N.S. 566, 385 feet 5 inches (Cooneana Formation).

Remarks:—Insufficient well preserved specimens have been observed to justify formal taxonomic treatment of this species.

Distribution:—Mount Crosby Formation, Colleges Conglomerate, Tivoli Formation, Cooneana Formation (this paper).

Subturma DISACCITES Cookson, 1947

Remarks:—In a recent paper Helby (in press) has interpreted the genus *Falcisporites* Leschik *emend.* Klaus, 1963 broadly, to include both colpate and leptomate forms and has assigned to it the species *Alisporites australis* de Jersey, 1962. Helby (in press) also believes that *Falcisporites* can be distinguished from specimens he assigns to *Alisporites opii* Daugherty, 1941 (the type species of *Alisporites*), which he considers to be neither colpate nor distinctly leptomate. However, although Helby's specimens, assigned to *A. opii,* came from the Chinle Formation (the original source of the species) the illustration of the holotype (Daugherty, 1941, pl. 34, fig. 2) depicts a feature (described as a fusiform furrow) which may represent a colpus or leptoma. Until the type material of *A. opii* is re-examined, it is not clear whether the holotype has a differentiated cappula (colpate or leptomate) or an undifferentiated cappula. In the former case *Alisporites* would have priority over *Falcisporites*: in the latter case it would be regarded as a distinct taxon. Consequently the writer prefers to await re-examination of the type material of *A. opii* before accepting transference of *A. australis* to *Falcisporites*. Pending such re-examination, grains of the *A. australis* type are included with other bisaccate grains (apart from the species recorded below) as "Disaccites (indet.)" as in other recent papers (de Jersey, 1970b, p. 14; 1971, p. 14).

Genus CHORDASPORITES Klaus, 1960

Type species:—*Chordasporites singulichorda* Klaus, 1960.

Chordasporites australiensis de Jersey, 1962

Remarks:—A well preserved specimen of this species, from the Blackstone Formation, has been figured recently (de Jersey, 1970b, pl. 6, fig. 1).

Distribution:—Triassic of Blackstone Formation, Tivoli Formation (de Jersey, 1962, 1970b, this paper); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Triassic of Tarong Beds, (de Jersey, 1970c).

Genus PLATYSACCUS Naumova ex Potonié & Klaus, 1954

Type species:—*Platysaccus papilionis* Potonié & Klaus, 1954.

Platysaccus queenslandi de Jersey, 1962

Distribution:—To the records listed by de Jersey (1971, p. 15) should be added Jain's report of the species (1968, p. 27) from the Cacheuta Formation of Argentina, the record by Bharadwaj and Srivastava (1969, p. 123) from the Nidpur assemblage of India and the writer's listing of its occurrence in the Tarong Beds (de Jersey, 1970c, pp. 309, 310). In the present study *P. queenslandi* has been observed in assemblages from the Colleges Conglomerate, Tivoli Formation and Cooneana Formation.

Genus SULCOSACCISPORA Klaus, 1964

Type species:—*Sulcosaccispora minuta* Klaus, 1964.

Sulcosaccispora alaticonformis (Malyavkina) de Jersey, 1968

Plate 4, Figure 8

Figured specimen:—Slide S2570, stage co-ordinates 10.4, 84.8; dimensions 44 x 46 microns. Co-ordinates of lower right hand corner of cover glass 26.0, 85.0.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—The specimen figured falls within the range of variation for Moolayember specimens of this species recorded by de Jersey and Hamilton (1967, pp. 15, 16; pl. 8, figs. 1-4).

Distribution:—Lower and Middle Triassic of U.S.S.R. (Malyavkina, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, upper Rewan

Formation (de Jersey, 1968, 1970a); Triassic of Wandoan Formation (de Jersey and Hamilton, 1969); Triassic of Blackstone Formation, Tivoli Formation (de Jersey, 1970b, this paper); Triassic of Hawkesbury Sandstone, Wianamatta Group of Sydney Basin (Helby, in press).

Genus VITREISPORITES Leschik *emend.* Jansonius, 1962

Type species:—*Vitreisporites signatus* Leschik, 1955.

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Remarks:—To the Queensland occurrences of this species, listed recently (de Jersey, 1971, p. 16) should be added records, based on the present study, from the Tivoli and Cooneana Formations.

Subturma STRIATITES Pant, 1954

Genus HAMIAPOLLENITES Wilson, 1962

Type species:—*Hamiapollenites saccatus* Wilson, 1962.

Hamiapollenites insculptus Playford & Dettmann, 1965

Plate 4, Figure 6

Figured specimen:—Slide S2568, stage co-ordinates 11.1, 90.4; total span 127 microns. Co-ordinates of lower right hand corner of cover glass 27.0, 82.9.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Distribution:—Triassic of Tivoli Formation, Blackstone Formation, Raceview Formation (Hill, Playford and Woods, 1965); de Jersey, 1970b, this paper); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965).

Turma ALETES Ibrahim, 1933

Subturma AZONALETES Luber *emend.* Potonié & Kremp, 1954

Infraturma PSILONAPITI Erdtman, 1947

Genus INAPERTUROPOLLENITES Pflug ex Thomson & Pflug *emend.* Potonié, 1966

Type species:—*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug *emend.* Potonié, 1966.

Inaperturopollenites spp.

Remarks:—Smooth or scabrate, inaperturate grains are recorded under this heading; specific differentiation has not been attempted.

Infraturma GRANULONAPITI Cookson, 1947

Genus ARAUCARIACITES Cookson ex Couper, 1953

Type species:—*Araucariacites australis,* Cookson, 1947.

Araucariacites spp.

Remarks:—Under this heading are recorded poorly preserved specimens, with sculpture of grana, rather than coni, as in *Conaletes.*

Genus CONALETES Reinhardt & Schön, 1967

Type species:—*Conaletes apiculatus* Reinhardt & Schön, 1967.

Conaletes spp.

Remarks:—Specific differentiation of these grains has not been attempted.

Genus DUPLICISPORITES Leschik *emend.* Klaus, 1960

Duplicisporites sp.

Plate 4, Figure 1

Figured specimen:—Slide S2582, stage co-ordinates 17.1, 95.0, diameter 33 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 82.6.

Locality:—N.S. 566, 899 feet 7 inches (Tivoli Formation).

Remarks:—The specimen figured resembles *Duplicisporites granulatus* Leschik *emend.* Klaus, 1960 in outline, size and distribution of the characteristic folds, but has only a faint indication of granulate sculpture. Because it is not clear whether this difference from *D. granulatus* is the result of poor preservation, or an original feature, formal comparison has not been made with that species. This is the only specimen of *Duplicisporites* recorded in the material studied.

Infraturma CIRCUMPOLLINI Pflug *emend.* Klaus, 1960

Genus DISCISPORITES Leschik *emend.* de Jersey, 1964

Type species:—*Discisporites niger* Leschik, 1955.

cf. *Discisporites psilatus* de Jersey, 1964

Plate 4, Figure 2

Figured specimen:—Slide S2569, stage co-ordinates 13.1, 92.6, diameter 36 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.8.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—The specimen figured closely resembles *Discisporites psilatus* in size, subtriangular outline and trilete character (compare, for example, pl. 6, fig. 10

of de Jersey, 1971) but lacks a clearly defined rimula. Instead of a rimula there is a distal fold which is concentric with the equatorial outline; the specimen is accordingly designated provisionally as cf. *Discisporites psilatus*.

This specimen is recorded as it is suggestive of a transition between *Grebespora concentrica* Jansonius, 1962 (which has a similar concentric fold and may exhibit a vestigial trilete mark) and *Discisporites psilatus* de Jersey, 1964. The suggestion that grains of the *Discisporites* type may have arisen by development of a rimula adjacent to the concentric fold is supported by the morphology of *Paracirculina maliawkinae* Klaus, 1960. In this species the sub-concentric fold and an adjacent rimula are both present on the distal exine; it could similarly be regarded as intermediate between *Grebespora concentrica* and *Discisporites psilatus*. *P. maliawkinae*, described from the Karnian of Austria by Klaus (1960, p. 163), differs from the Queensland specimen mainly in having the fold interrupted in two, or occasionally three, places.

Turma PLICATES Naumova *emend.* Potonié 1960

Subturma POLYPLICATES Erdtman, 1952

Genus EQUISETOSPORITES Daugherty *emend.* Pocock & Jansonius, 1964

Type species:—*Equisetosporites chinleana* Daugherty, 1941.

Equisetosporites sp.

Plate 5, Figure 7

Figured specimen:—Slide S2704, stage co-ordinates 21.2, 90.3; dimensions 61 x 25 microns. Co-ordinates of lower right hand corner of cover glass 28.0, 82.4.

Locality:—N.S. 566, 2010 feet (Colleges Conglomerate).

Remarks:—The specimen figured is the only representative of this genus observed in the Tivoli-Kholo assemblages. Excluding specimens recorded as "Gen. nov. A" (de Jersey, 1970b, pp. 17, 18; this paper) which may possibly be of ephedroid affinity, it is thus the only example of ephedroid pollen as yet recorded from the Ipswich Coal Measures. Specific identification must await the discovery of more, and better preserved, specimens.

Gen. nov. A

Remarks:—A fragmentary specimen specifically identifiable with grains recorded under this heading from the Blackstone Formation (de Jersey, 1970b, pp. 17, 18) has been observed in an assemblage from the Cooneana Formation.

Distribution:—Blackstone Formation (de Jersey, 1970b); Cooneana Formation (this paper).

Subturma MONOCOLPATES Wodehouse, Iversen & Troels-Smith, 1953

Genus CYCADOPITES Wodehouse ex Wilson & Webster, 1946

Type species:—*Cycadopites follicularis* Wilson & Webster, 1946.

Remarks:—Jansonius (1962, p. 80) interpreted this genus broadly to include grains ranging from broadly oval to fusiform in outline and having smooth, ornamented or intrapunctate exines. This interpretation is followed here. Other authors, notably Herbst (1965, pp. 147-149) and Jain (1968, pp. 34, 35) have used *Cycadopites* in a more restricted sense.

Features by which other genera have been separated from *Cycadopites* are based either on the shape of the colpus or presence of various types of exine sculpture. Of these criteria the former appears unreliable, in view of the continuous variation evident in the shape of the colpus, in grains which are otherwise similar; the colpus shape seems likely to be affected by maturity and preservation of the grains. The latter criterion, (exine sculpture) seems more promising as a means of generic differentiation. However the sculptural elements are so fine in some of the ornamented species that they are difficult to study in detail under the light microscope. It appears preferable to await a comprehensive study of the surface sculpture of grains of the *Cycadopites* type, with the aid of the scanning electron microscope, before arriving at a final decision on generic grouping. Pending such study (for which these grains appear ideally suited), *Cycadopites* is used in the broad sense of Jansonius, to accommodate *C. granulatus* (de Jersey) de Jersey, 1964 and the finely ornamented species, *C. tivoliensis* sp. nov., described below.

Cycadopites crassimarginis (de Jersey) de Jersey, 1964

Distribution:—Triassic of Colleges Conglomerate, Tivoli Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation (de Jersey, 1962, 1964, 1970b, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967).

Cycadopites granulatus (de Jersey) de Jersey, 1964

Distribution:—Triassic of Colleges Conglomerate, Tivoli Formation, Blackstone Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1971, this paper); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Jurassic of Marburg Formation (de Jersey, 1971).

Cycadopites nitidus (Balme) de Jersey, 1964

Remarks:—Helby (in press) has listed this species as a synonym of *Cycadopites follicularis* Wilson & Webster, 1946. There is, indeed, little to distinguish the species, on the basis of the published descriptions

(Wilson and Webster, 1946, p. 274; Balme 1957, p. 30). Although grains of both these species appear to have unsculptured exines, when examined with the light microscope, it is possible that fine sculpture may be revealed by the scanning election microscope. If so, grouping of these apparently smooth grains into narrower taxonomic units may be possible. Accordingly, pending such studies, the conservative course has been followed, of assigning the Queensland specimens to an Australian Mesozoic species, rather than to one described from the Tertiary of the United States.

Distribution:—Specimens assigned to *C. nitidus* are widespread in the Mesozoic of Australia; for Queensland records of the species, reference should be made to de Jersey (1971, p. 20). Helby (in press) has recently recorded grains of this type from the Hawkesbury Sandstone and Wianamatta Group of the Sydney Basin.

Cycadopites tivoliensis sp. nov.

Plate 5, Figures 2, 3, 5 and 8

Diagnosis:—Amb elongate oval, extremities pointed to rounded. Length (based on 19 measured specimens) 66 to 115 microns; breadth 21 to 41 microns. Monocolpate, colpus extending full length of distal surface, relatively narrow and usually of uniform width. Margins of colpus distinctly thickened for a width of about 5 to 10 microns. Exine about 1 to 2 microns in thickness, with fine sculpture, dominantly conate; coni about 0.5 to 1 micron apart. Sculptural elements may include minor proportions of spinae and bacula, about 1 micron in height and 0.5 micron in basal diameter.

Holotype (*Plate* 5, *Figures* 5 *and* 8):—Slide S2569, stage co-ordinates 8.3, 93.6; dimensions 76 x 25 microns. Co-ordinates of lower right hand corner of cover glass 26.7, 84.8. (Plate 5, Figure 5 is an oil-immersion photograph (x2000) showing the fine sculpture in part of the equatorial region of this specimen).

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Figured specimen (*Plate* 5, *Figure* 2):—Slide S2570, stage co-ordinates 15.0, 90.8; dimensions 79 x 26 microns. Co-ordinates of lower right corner of cover glass 26.0, 85.0.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Figured specimen (*Plate* 5, *Figure* 3):—Slide S2571, stage co-ordinates 7.6, 102.3, dimensions 87 x 28 microns. Co-ordinates of lower right hand corner of cover glass 27.2, 86.1.

Locality:—N.S. 566, 597 feet 9 inches (Tivoli Formation).

Remarks:—The specific name refers to provenance of the type material from the Tivoli Formation. Distinctive features of this species are its relatively large size, the presence of exinal thickenings adjacent to the colpus and the finely conate sculpture. The former features are illustrated in Plate 5, Figures 2, 3 and 8. Portion of the exine of the holotype, showing the fine sculpture, is illustrated in Plate 5, Figure 5. In the specimens studied, the sculpture appears to be delicate and may be partially removed (? by corrosion or abrasion). Specimens so affected have smooth featureless areas of exine; accordingly it is suggested that two specimens recorded from the Raceview Formation (de Jersey, 1971, p. 20) as *Cycadopites magnus* Herbst, 1965 may represent specimens of *C. tivoliensis* from which the fine, delicate surface sculpture has been removed. The same possibility exists, with regard to the type material of *C. magnus* Herbst, 1965, a species based on only two specimens (Herbst, 1965, p. 149). The latter is described as having a smooth exine, but study of further specimens is desirable to establish clearly its relationship to *C. tivoliensis*.

Among described species, with sculptured exines, both *C. subgranulosus* (Couper) Bharadwaj & Singh, 1964 and *C. granulatus* (de Jersey) de Jersey, 1964 are appreciably smaller and lack the prominent exinal thickenings of *C. tivoliensis*. The predominantly conate sculpture of the latter also appears to be somewhat different from that of these species. A species recorded by Jain (1968, p. 36) as *Granamegamonocolpites cacheutensis* lacks the exinal thickenings of *C. tivoliensis* and also differs in having granulate to verrucate, rather than conate, sculpture. No close comparison can be made with other described species.

Distribution:—Tivoli Formation, Mount Crosby Formation (this paper).

Turma	Poroses Naumova *emend.* Potonié, 1960
Subturma	Monoporines Naumova, 1939
Genus	Pilasporites Balme & Hennelly *emend.* Jain, 1968

Type species:—*Pilasporites calculus* Balme & Hennelly, 1956.

Remarks:—The emended diagnosis of Jain (1968, p. 42) based on the type species, *P. calculus*, appears to provide a reasonable interpretation of the morphology of these pollen grains and, as indicated previously (de Jersey, 1971, p. 16) is accepted by the writer. Re-examination of the Permian type material is, however, desirable to confirm this interpretation.

Pilasporites crateraformis Jain, 1968

Plate 5, Figures 1, 4 and 6

Figured specimen (*Plate* 5, *Figure* 1):—Slide S2582, stage co-ordinates 18.1, 93.4; diameter 53 microns. Co-ordinates of lower right hand corner of cover glass 26.4, 82.6.

Locality:—N.S. 566, 899 feet 7 inches (Tivoli Formation).

Figured specimen (*Plate* 5, *Figure* 4):—Slide S2578, stage co-ordinates 18.7, 95.8; diameter 59 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 83.6.

Locality:—N.S. 566, 789 feet 4 inches (Tivoli Formation).

Figured specimen (*Plate* 5, *Figure* 6):—Slide S2581, stage co-ordinates 9.6, 85.6; diameter 68 microns. Co-ordinates of lower right hand corner of cover glass 26.5, 84.5.

Locality:—N.S. 566, 899 feet 7 inches (Tivoli Formation).

Remarks:—The specimens figured illustrate the smooth to scabrate exine, "monoporate" character and gradation from circular to sub-triangular outline and from circular to sub-triangular opening typical of this species. They are thus regarded as conspecific with the grains described by Jain (1968, pp. 42, 43, pl. 12, figs. 217-220); their diameter (based on 26 measured specimens) ranges from 46 to 89 microns.

Sub-triangular specimens of this species are reminiscent of separated portions of *Araucariacites fissus,* from the Jurassic of the Surat Basin (Reiser and Williams, 1969, p. 17, p. 5, figs. 11-17). However the Ipswich grains show no sign of splitting, as described in the Jurassic species; furthermore no specimens with sub-circular openings, as in variants of *P. crateraformis,* are recorded in *A. fissus.* From this evidence the species are regarded as distinct.

Distribution:—Middle Triassic of Cacheuta Formation, Argentina (Jain, 1968); Triassic of Tarong Beds, Queensland (de Jersey, 1970c); Triassic of Cooneana Formation, Tivoli Formation, Colleges Conglomerate (this paper). The species has also been observed in an assemblage from the Blackstone Formation (N.S. 272, 2289 feet 8 inches).

Group ACRITARCHA Evitt, 1963

Subgroup SCHIZOMORPHITAE Segroves, 1967

Genus CIRCULISPORITES de Jersey *emend.* Norris, 1965

Circulisporites parvus de Jersey *emend.* Norris, 1965

Distribution:—Recorded from the Permian and Mesozoic of Australia, South Africa and Antarctica. Queensland records: Triassic of Mount Crosby Formation, Tivoli Formation, Aberdare Conglomerate, Raceview Formation, Ripley Road Sandstone (de Jersey, 1962, 1964, 1970b, this paper); Triassic of Tingalpa Formation, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Tarong Beds (de Jersey, 1970c); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Jurassic of Marburg Formation (de Jersey, 1963, 1971); Jurassic of Evergreen Formation, Hutton Sandstone of Surat Basin (de Jersey and Paten, 1964).

MICROFLORAL SEQUENCE IN THE IPSWICH COAL MEASURES

As indicated in the Introduction of this paper, a primary objective of the investigation has been to study assemblages distributed through the complete vertical sequence of the Tivoli Formation and Kholo Sub-Group. In conjunction with the previous study of the Blackstone Formation (de Jersey, 1970b), this would provide a record of miospore distribution through the entire succession of the Ipswich Coal Measures. This objective has been substantially achieved; although unfavourable lithology and poor preservation of some of the assemblages have reduced coverage of some parts of the sequence, sufficient is now known of the assemblages to enable assessment of the stratigraphic significance of the species present.

Miospore assemblages recorded in the present study are listed in the Appendix of this paper; those from the Blackstone Formation have been previously recorded (de Jersey, 1970b, pp. 38-41; Figure 2). Two general conclusions emerge from study of these assemblages. They are, firstly, that the shale samples have yielded a much greater variety of species than previously recorded from the Ipswich coals and, secondly, that the vast majority of the species present are relatively long-ranged. The second conclusion is based not only on the extended ranges of many of them, in the Ipswich sequence, but also on knowledge of their distribution in other areas. The latter evidence is significant in the case of species which are sporadically distributed within the Ipswich sequence. Thus, for example, *Hamiapollenites insculptus* has only been recorded in two assemblages from the Tivoli Formation (from 597 feet 9 inches and 1395 feet 11 inches in N.S. 566). However this species is known to be long-ranged in the Triassic of Queensland, having been recorded from the Lower Triassic Rewan Formation, the Middle Triassic Moolayember Formation, and Upper Triassic Raceview Formation. Its presence in these two Tivoli assemblages is thus considered to indicate, not that its range is restricted to the Tivoli Formation, but that, presumably because of adverse environmental factors, specimens were not preserved in assemblages from the remainder of the sequence.

Similar considerations apply to most of the other species which are sporadically distributed in the Ipswich sequence. On the basis of knowledge of the ranges of the species, in the Australian Triassic, and their distribution in the Ipswich sequence. only three of them appear to have restricted ranges, within the succession. These are *Cycadopites tivoliensis* (confined to the Tivoli Formation and Kholo Sub-Group), *Lycospora pallida* (confined to the Tivoli Formation) and *Stereisporites* sp. A (confined to the Blackstone Formation). The presence of one of these species in an assemblage would favour assignment to, or correlation with, the relevant part of the succession, but they are too sporadically distributed, or in the case of *Stereisporites* sp. A, too rare to be used in formal biostratigraphic zonation. The available evidence does, in fact, favour the view that only one biostratigraphic unit, based on miospore assemblages, can be recognized for the whole sequence of the Ipswich Coal Measures.

The explanation favoured for this dominance of species, which range through the Ipswich Coal

Measures, is that sediments of the Group were deposited in a relatively short interval of Triassic time. Evidence for rapid deposition is provided by the lithology of the sediments, particularly in the lower part of the succession. At the base of the sequence the Kholo Sub-Group, in its total thickness of about 1100 feet, includes over 900 feet of conglomerate, the greater part of which (the Colleges Conglomerate) is regarded as "the product of rapid erosion of a provenance of high relief" (Allen, 1961, p. 11). The overlying Tivoli Formation contains a large proportion of coarse, often pebbly sandstone; similar sediments are also dominant in the Cooneana Formation. The only formation in the sequence containing a large proportion of fine grained sediments (shale, siltstone and coal) indicating a slower rate of deposition, is the Blackstone Formation, but this unit only attains a maximum thickness of about 800 feet, out of a total for the Group of about 4,300 feet.

In advancing this evidence for relatively rapid deposition of the Ipswich Coal Measures, greater emphasis is placed on miospore distribution, than on the gradual changes in composition of the macrofloras, noted by Jones and de Jersey (1947, p. 65, Table 1). There are two significant reasons for placing greater reliance on the miospores. Firstly, the studies of miospore distribution are based on much larger numbers of specimens; although Jones and de Jersey (1947, p. 1) examined about 6000 specimens of plant macrofossils, the number of miospore specimens examined from the Ipswich succession would be much greater. Secondly, the miospores are likely to provide a more comprehensive record of the Ipswich flora than the macro-fossils, which require a more restricted set of conditions for their preservation. Evidence supporting this view is provided by the presence of five species of *Aratrisporites*. From what is known of the affinities of spores of this type, they are likely to be derived from herbaceous lycopods, a group which is not represented in the macro-fossil record. Similar considerations probably apply to other miospore species. Accordingly, it seems probable that the gradual change in the character of the macroflora within the sequence (Jones and de Jersey, 1947, p. 65) is a reflection of environmental changes, selectively affecting preservation of various species, and that their maximum stratigraphic ranges, in general, appreciably exceed those recorded.

Although, as indicated above, there are few significant changes in the microfloras within the Ipswich Coal Measures, the miospore population is appreciably different from that of the overlying Bundamba Group. As shown recently (de Jersey, 1970b, pp. 19, 20) some species disappear from the assemblages and others are introduced, important elements of the younger microflora being *Gliscopollis meyeriana* and *Polycingulatisporites crenulatus*. The appearance of these younger elements above the disconformity between the two groups constitutes the most important change, from the biostratigraphic aspect, within the Triassic microfloral sequence of the Ipswich area.

COMPARISON WITH OTHER AUSTRALIAN TRIASSIC MICROFLORAS

An important result of the present investigation is that it supports the view (de Jersey and Hamilton, 1967, p. 23; de Jersey, 1970b, p. 20) that the Ipswich Coal Measures are younger than the Moolayember Formation of the Bowen Basin. The Tivoli-Kholo assemblages, like those of the Blackstone Formation, previously described, are lacking in Moolayember species which include *Accinctisporites ligatus, Aratriporites plicatus, A. strigosus, A. wollariensis, Cadargasporites senectus, Densoisporites playfordi, Grebespora concentrica, Kraeuselisporites verrucifer, Nevesisporites limatulus, Rugulatisporites stonecrofti, R. trisinus, Tigrisporites playfordi* and *Verrucosisporites carnarvonensis*. Ipswich species, not recorded in the Moolayember assemblages, include *Acanthotriletes bradiensis, Anapiculatisporites pristidentatus, Annulispora folliculosa, A. microannulata, Apiculatisporis globosus, Aratrisporites flexibilis, Baculatisporites comaumensis, Cadargasporites baculatus, Craterisporites rotundus, Cycadopites tivoliensis, Polycingulatisporites densatus, Pustulatisporites blackstonensis* and *Stereisporites perforatus*. An additional difference is that *Duplexisporites problematicus*, which is common in most of the Ipswich assemblages, is rare or absent in those from the Moolayember Formation.

Among the many differences between the assemblages from the two units, two are considered particularly significant. They are (1) the widespread distribution of spores with distal circumpolar muri (*Annulispora* spp. and *P. densatus*) in the Ipswich Coal Measures and their extreme rarity in the older assemblages, and (2) the presence of *Cadargasporites baculatus* in the Ipswich microflora. The occurrence of the former species in the Ipswich assemblages is not merely a reflection of the coal-measure environment, as spores of *Annulispora* are widespread in Lower Jurassic sediments of the Surat Basin (Reiser and Williams, 1969) which contain little coal. Likewise *C. baculatus* has been found in lithologically diverse sequences, representing both coal and non-coal environments. Species of *Cadargasporites* from older formations have much finer sculptural elements, quite distinct from the spinose—baculate projections of *C. baculatus*.

Additional support for this distinction between the Moolayember and Ipswich microfloras is provided by recent evidence for lateral persistence of the latter. Samples from the Tarong Beds, in the Nanango district, have yielded assemblages of Ipswich aspect (de Jersey, 1970c). From the presence of *Lycospora pallida*, recorded above, in one of the Tarong assemblages, it is suggested that the relatively thin Tarong sequence is approximately coeval with the Tivoli Formation.

In the Brisbane area, microfloras from the Tingalpa and Moorooka Formations are also of Ipswich aspect (de Jersey and Hamilton, 1965b, p. 332, de Jersey, 1970b, p. 20). On the basis of the present investigation, no more precise correlation can be attempted for the Moorooka Formation, but the presence of *L. pallida* in one of the Tingalpa assemblages is suggestive of correlation with the Tivoli Formation.

As discussed previously (de Jersey, 1970b, p. 21) miospore assemblages from two other areas in Australia are similar to, and regarded as approximately coeval with, microfloras from the Ipswich Coal Measures. These comprise assemblages from the Brady Formation and "Feldspathic Sandstone" of Tasmania, described by Playford (1965), and the older (Triassic) microflora of the Leigh Creek Coal Measures of South Australia (Playford and Dettmann, 1965). Little can be added to this previous discussion, except to state that, because these Tasmanian and South Australian sequences comprise thinner sections of sediments, they may represent time equivalents of some portion, or portions of the Ipswich Coal Measures.

No close comparison can be made between the Ipswich microflora and miospore assemblages described from Western Australia by Balme (1963) and from New South Wales by Helby (1967; in press). All these assemblages are much more closely comparable with microfloras from the Triassic of the Bowen Basin, which as discussed above, are regarded as entirely pre-Ipswich in age.

AGE OF THE IPSWICH COAL MEASURES

From the preceding section it is evident that studies of miospore assemblages are providing much valuable data on the relative ages of Australian Triassic formations. If progress continues at the present rate, it seems likely that in the next few years it will be possible to relate most of the Triassic deposits of the continent to a composite sequence, on the basis of miospore distribution. It is much more difficult. however, to relate the Australian deposits to the standard Triassic sequence, based on marine faunas. This is because the only sediments from which accurately dated invertebrate faunas have been described are of Lower Triassic age. The Middle and Upper Triassic formations are, in most cases, continental deposits containing (apart from miospores) leaf and vertebrate fossils, which are, in general, less precise indicators of age, than marine invertebrates.

A further difficulty arises from the differences between the Triassic "Northern" floras and those of the Gondwana regions. From the megafossil record it would appear that Triassic floras of the two hemispheres have so little in common that there is little hope of correlation between them. However, a different picture emerges when the microfloras are considered, as there is a significant proportion of miospore species common to both Australian and Northern (European and North American) microfloras. It can only be concluded, as has been pointed out by Chaloner (1969, p. 292) in the case of the Triassic Lycopods, that the spore and pollen assemblages provide, in general, a more complete record of the floras than the megafossils. It follows that the two provinces cannot be regarded as entirely mutually exclusive and it seems likely that some migration took place between them.

Evidence on the age of the Blackstone Formation, based on the distribution of miospore species, which are also present in the European Triassic, has been recently discussed (de Jersey, 1970b, p. 22). From the evolutionary aspect, the first appearance of pollen grains with a rimula (ring-tenuitas) is considered significant. Such grains, including in particular the distinctive species *Gliscopollis meyeriana,* are persistently present in Europe above the base of the Norian Stage. In Queensland, this species has been recorded from the Bundamba Group; its absence from the Blackstone Formation (and also from the Tivoli-Kholo assemblages) is evidence for a pre-Norian age. On the other hand, the presence of *Apiculatisporis globosus* and *Stereisporites perforatus,* which first appear in Europe in sediments of Karnian age, indicates a maximum age—not older than Karnian—for the Blackstone Formation and for the Tivoli Formation, from which they are now also recorded. Only one of them, *S. perforatus,* is listed from the Kholo Sub-Group, but the unfavourable lithology of these basal sediments has not been conducive to study in as much detail as the higher formations. In any case lithological evidence for rapid deposition of the Kholo sediments would indicate that the time interval they represent is relatively short, in comparison with the rest of the Ipswich sequence. Accordingly, a Karnian age is assigned to the Ipswich Coal Measures in Table 1, below, in which are also shown ages suggested for other Triassic formations of Queensland, on the basis of miospore distribution.

Additional support for assigning a Karnian, rather than a Middle Triassic, age to the Ipswich microflora is provided by the general composition of the assemblages, particularly by the low proportion of striate bisaccate pollen. Grains of this type are relatively uncommon in the Ipswich material and confined to one species—*Hamiapollenites insculptus*—in contrast to the significantly greater abundance and specific diversity of striate grains recorded from the Middle Triassic of the Northern Hemisphere (Klaus, 1964; Schulz, 1966; Visscher and Commissaris, 1968; and Antonescu, 1970) and the Southern Hemisphere (Jain, 1968). In having a low proportion of striate grains the Ipswich microflora conforms more closely to Late Triassic microfloras, in line with the general decline in the proportion and variety of the Striatites from the Early Triassic onwards.

Other evidence on the age of the Ipswich Coal Measures is derived from plant macro-fossils, fossil insects and vertebrate remains. Regarding the former, Jones and de Jersey (1947, p. 82) suggested a Middle Triassic age. This conclusion was based largely on the similarity of the Ipswich flora to those from the Wianamatta Group of New South Wales and from parts of the Molteno-Upper Beaufort sequence of South Africa, both dated by vertebrate evidence as Middle Triassic. Unfortunately in each case the floras were the youngest described in the Triassic sequences of the areas concerned; if accurately dated Upper Triassic floras had been available for comparison even closer similarities may have been found.

These earlier conclusions on the age of the Ipswich flora must also be re-interpreted in the light of present

	GERMANIC GROUPS	ALPINE STAGES	BOWEN BASIN (Eastern Mimosa Syncline)	TARONG AREA	MORETON BASIN	IPSWICH BASIN
LATE TRIASSIC	KEUPER	RHAETIAN			Ripley Rd. Sst.	
					Raceview Fmn.	
					Aberdare Cgl.	
		NORIAN				
		KARNIAN		Tarong Beds		Ipswich Coal Measures
MIDDLE TRIASSIC		LADINIAN				
	MUSCHELKALK	ANISIAN	Moolayember Formation			
			Clematis Sandstone			
EARLY TRIASSIC	BUNTSANDSTEIN	SCYTHIAN	Rewan Formation			

Table 1 — Showing ages of Ipswich Coal Measures and other Triassic formations (based on miospore assemblages).

evidence, for relatively rapid deposition of the sediments. As indicated, there is evidence that the sequence was deposited in a relatively restricted portion of Triassic time. In general terms, the present evidence from miospore distribution is regarded as somewhat more precise, in assigning the Group to a slightly later, more restricted portion of the Triassic.

Concerning the fossil insects, these are incompletely described, only eight species having been recorded from the Mount Crosby Formation. From the upper insect bed, in the Blackstone Formation (at Denmark Hill), 122 species have been described; Tillyard (in Tillyard and Dunstan, 1924) regarded this fauna as Late Triassic.

More recent evidence on the age of the Group is forthcoming from vertebrate fossils. As indicated above, the Ipswich microflora is significantly younger than that of the Moolayember Formation. Assemblages from the latter are similar to those of the Wianamatta Group of New South Wales and these units are regarded as approximately coeval (Helby, in press). Labyrinthodont and fish faunas of the Wianamatta Group are of Middle Triassic aspect (Dr. Anne Howie, pers. comm.); thus the Karnian age attributed here to the Ipswich Coal Measures is supported by this indirect evidence. More directly, it is also supported by evidence from fossil footprints located in the Rhondda Colliery, in workings on the Striped Bacon seam, within the Blackstone Formation. These footprints "represent considerable evolutionary development beyond the condition ancestral to the dinosaurs observed in the Lower and Middle Triassic thecodont reptiles (Bartholomai, 1966, p. 148)". Thus in this case also, vertebrate evidence is more in conformity with a Karnian (early Late Triassic) than a Middle Triassic, age for the Ipswich Coal Measures.

These conclusions on the age of the Ipswich Coal Measures, in relation to other Triassic formations from which microfloras have been studied, are illustrated in Table 1, on page 21.

ACKNOWLEDGMENTS

The material examined was obtained from the cores of two holes drilled by the Department of Mines in the Ipswich area. They are N.S. 566 (Ipswich) and G.S.Q. Ipswich 16, drilled under the geological supervision of the Coal and Petroleum Sections of the Geological Survey, respectively. With regard to N.S. 566, Mr. D. C. Mengel furnished advice on the lithology and stratigraphy of the section penetrated; Mr. R. J. Allen assisted similarly, in respect of G.S.Q. Ipswich 16. Dr. R. Helby, of the Geological Survey of New South Wales, kindly made available the text and plates of his paper on the Sydney Basin, prior to publication. For the opportunity to examine holotypes and other specimens of *Aratrisporites flexibilis* and *A. paenulatus,* the writer is indebted to Dr. G. Playford, of the Geology Department, University of Queensland. Discussion of taxonomic problems with both workers has been most helpful. Mr. R. Beaugeais, of the Palynology Section of the Geological Survey, was responsible for laboratory processing of the samples and also assisted in preparation of the photomicrographs and plates. The assistance of Mr. J. R. Kay, who undertook preparation of the locality map and correlation diagram, is also gratefully acknowledged.

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PLATE 1

(All photographs approximately × 1000)

Figure 1—*Stereisporites antiquasporites* (Wilson & Webster) Dettmann, 1963 (median focus).

Figure 2—*Stereisporites perforatus* Leschik, 1955 (distal focus).

Figure 3—*Anapiculatisporites pristidentatus* Reiser & Williams, 1969 (distal-equatorial focus).

Figure 4—*Uvaesporites verrucosus* (de Jersey) Helby, comb. nov. (median focus, showing trilete character).

Figure 5—*Uvaesporites verrucosus* (de Jersey) Helby, comb. nov. (median focus, showing trilete character and intexine).

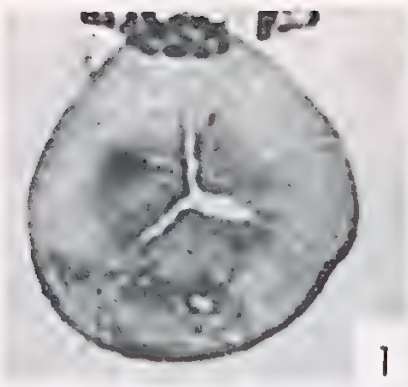
Figure 6—*Uvaesporites verrucosus* (de Jersey) Helby, comb. nov. (distal-equatorial focus, showing cavity between exine layers, simulating a rimula).

Figure 7—*Uvaesporites verrucosus* (de Jersey) Helby, comb. nov. (proximal focus, showing trilete character).

Figure 8—*Craterisporites rotundus* de Jersey, 1970 (median focus).

Figure 9—*Apiculatisporis globosus* (Leschik) Playford & Dettmann, (median focus).

Figure 10—*Pustulatisporites blackstonensis* de Jersey, 1970 (median focus).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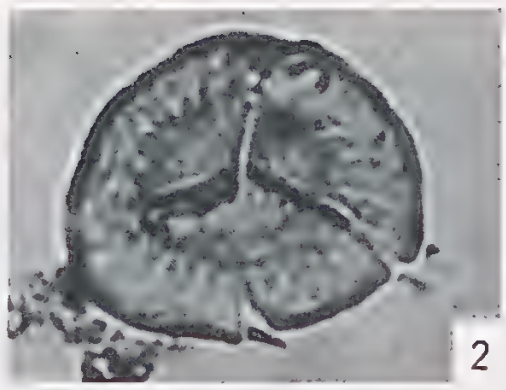
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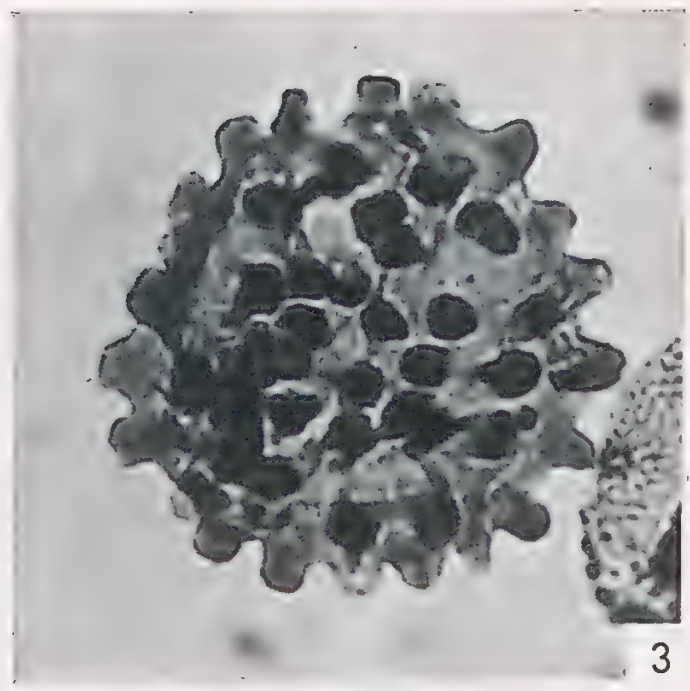
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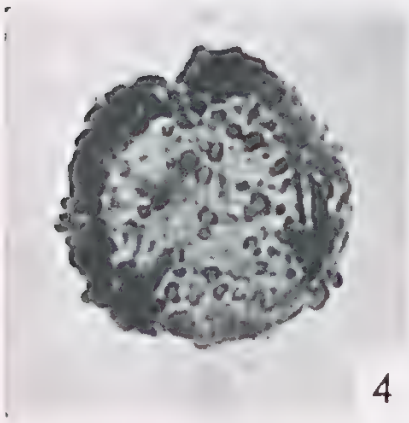
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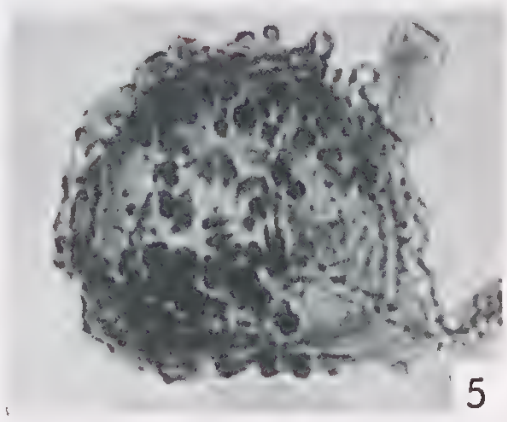
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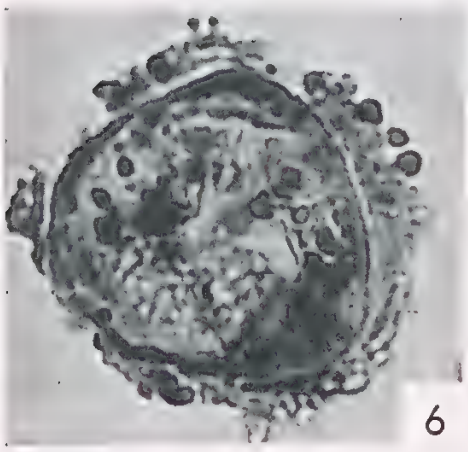
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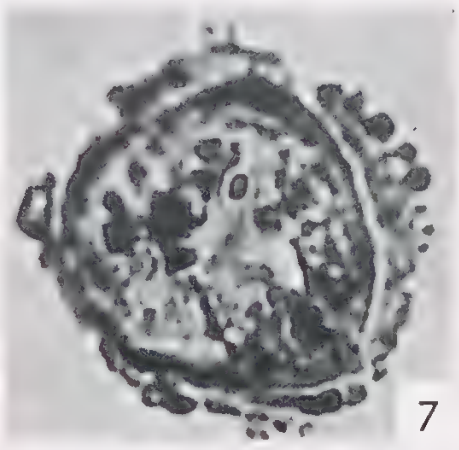
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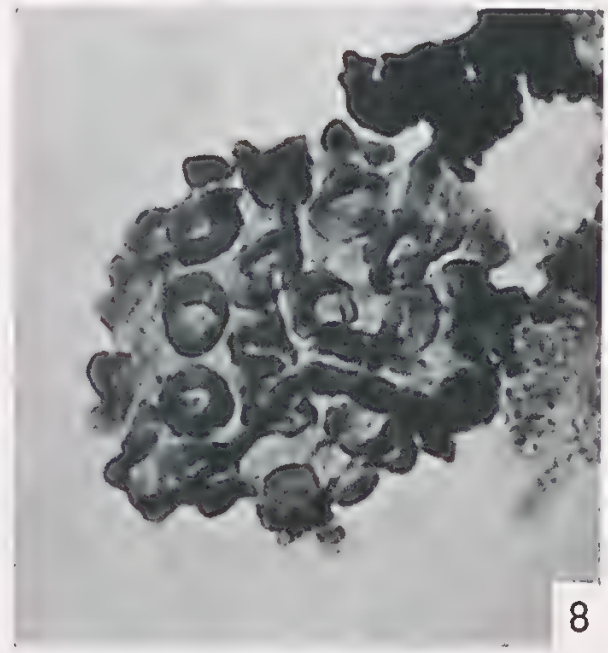
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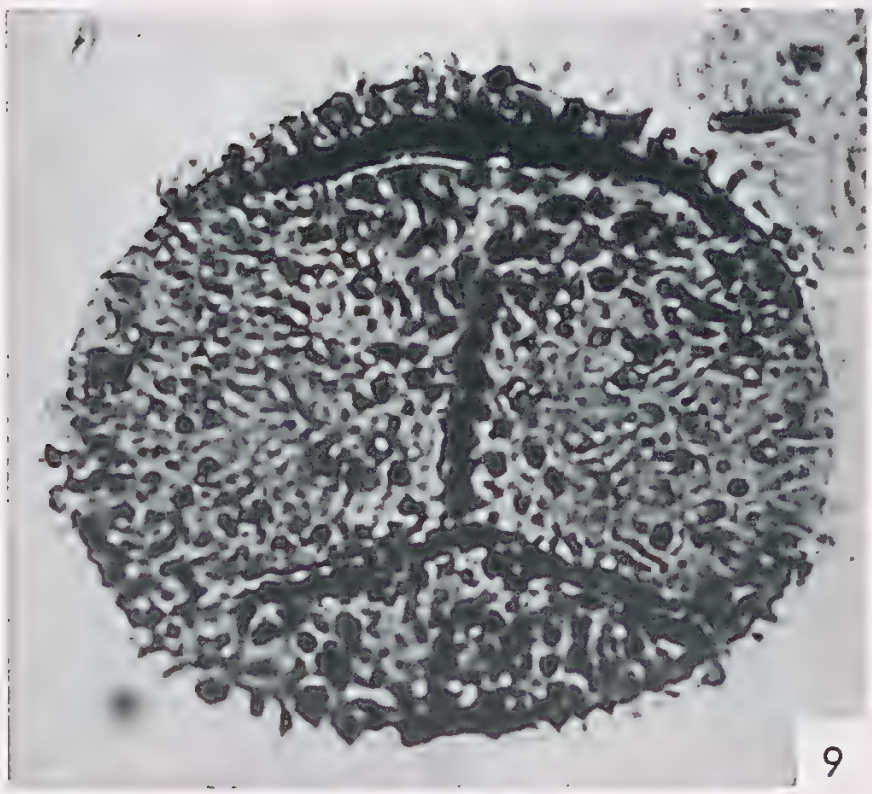
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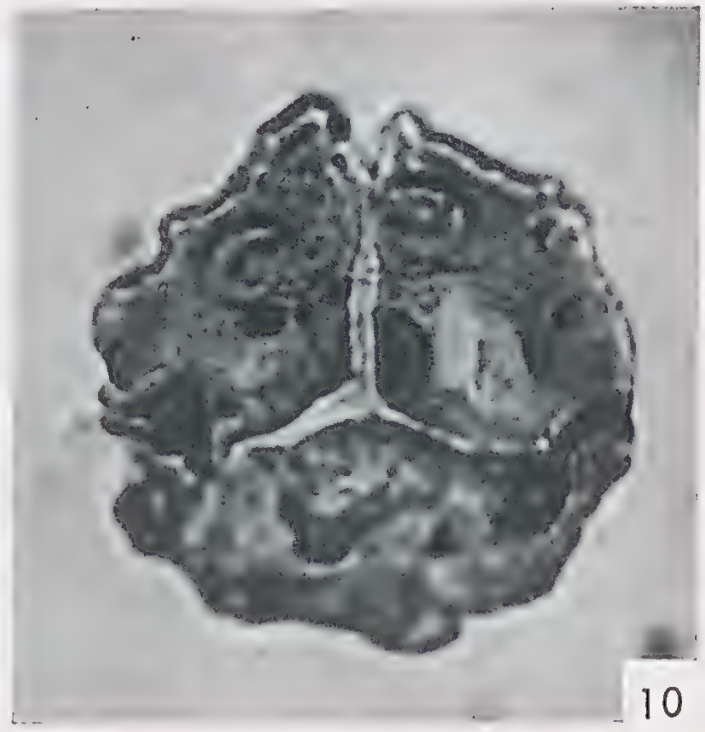
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PLATE 1

PLATE 2

(All photographs approximately × 1000)

Figure 1—*Cadargasporites baculatus* de Jersey & Paten *emend.* Reiser & Williams, 1969 (proximal focus).

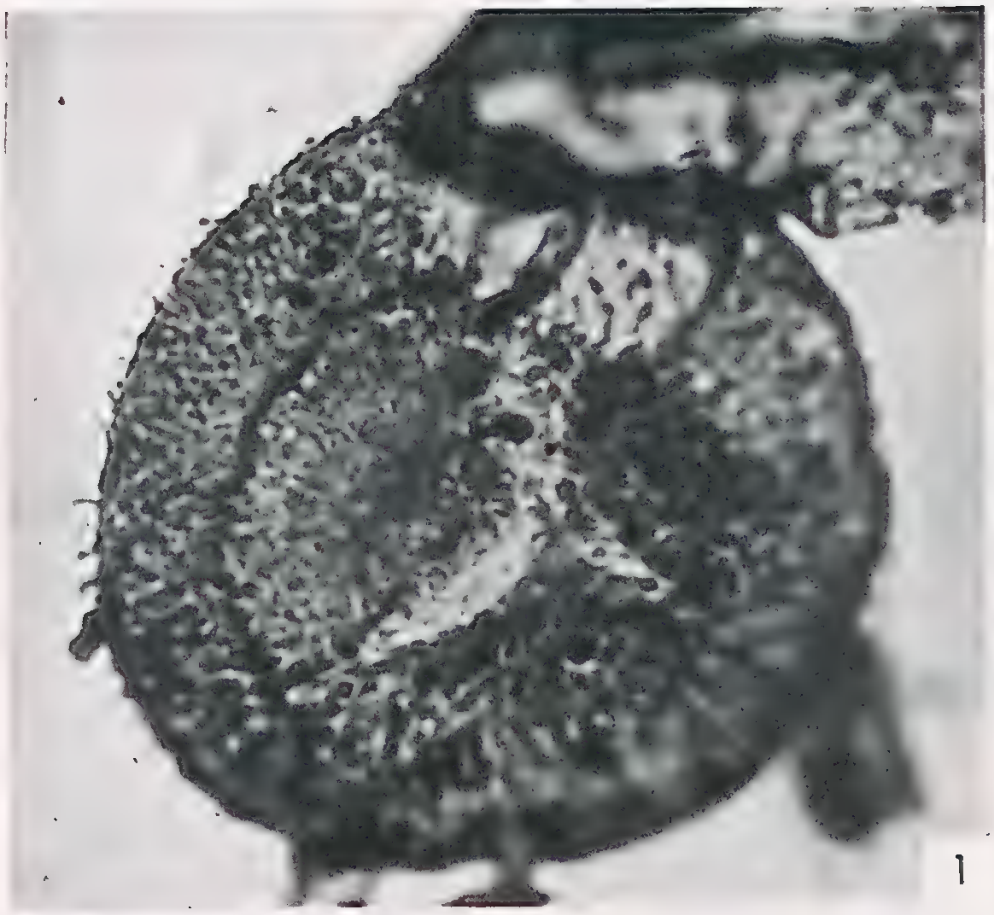
Figure 2—*Baculatisporites comaumensis* (Cookson) Potonié, 1956 (equatorial focus).

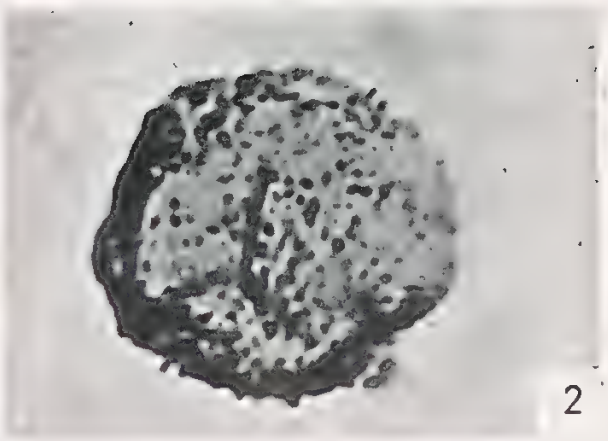
Figure 3—*Duplexisporites problematicus* (Couper) Playford & Dettmann, 1965 (median focus).

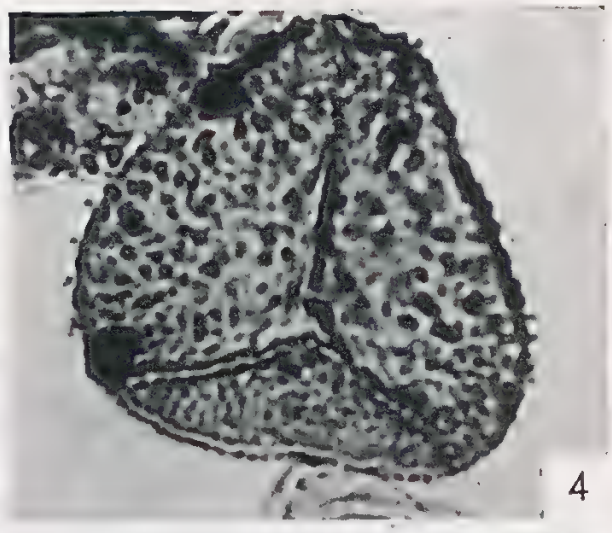
Figure 4—*Conbaculatisporites* sp. cf. *C. mesozoicus* Klaus, 1960 (equatorial focus).

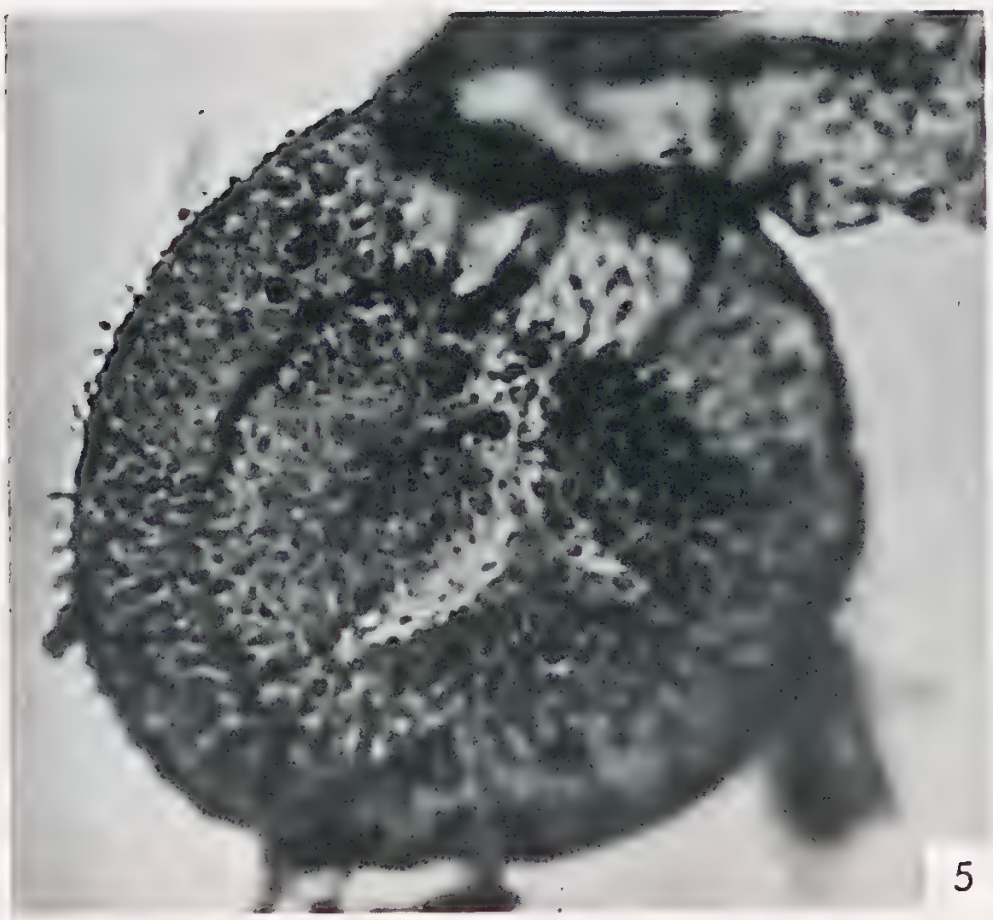
Figure 5—*Cadargasporites baculatus* de Jersey & Paten *emend.* Reiser & Williams, 1969 (distal focus).

Figure 6—*Acanthotriletes bradiensis* Playford, 1965 (equatorial focus).









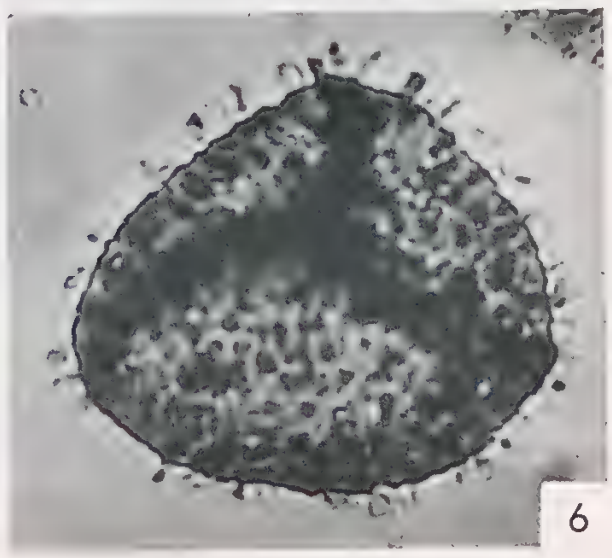


PLATE 2

PLATE 3

(All photographs approximately × 1000)

Figure 1—*Annulispora folliculosa* (Rogalska) de Jersey, 1959 (distal focus).

Figure 2—*Annulispora microannulata* de Jersey, 1962 (median focus).

Figure 3—*Lycospora pallida* (de Jersey) de Jersey, comb. nov. (proximal focus, showing lipped laesurae and intexine).

Figure 4—*Lycospora pallida* (de Jersey) de Jersey, comb. nov. (proximal focus showing lipped laesurae, intexine, equatorial spinae and bacula).

Figure 5—*Lycospora pallida* (de Jersey) de Jersey, comb. nov. (distal focus, same specimen as Figure 4, showing distal rugulae joined to form an imperfect reticulum).

Figure 6—*Lycospora pallida* (de Jersey) de Jersey, comb. nov. (distal focus, same specimen as Figure 3, showing discrete sculptural elements).

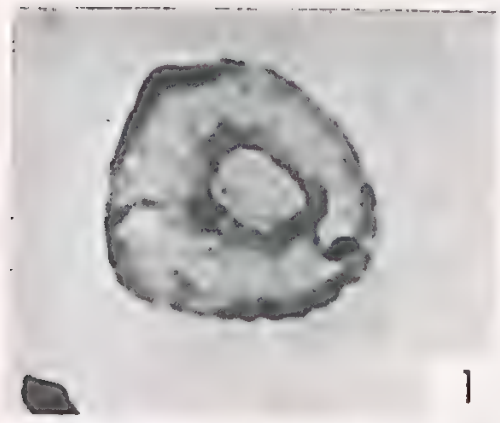
Figure 7—*Rewanispora foveolata* de Jersey, 1970 (proximal focus, showing laesurae and shrunken intexine).

Figure 8—*Rewanispora foveolata* de Jersey, 1970 (distal focus, same specimen as Figure 7, showing foveolate sculpture).

Figure 9—*Aratrisporites* sp. cf. *A. granulatus* (Klaus) Playford & Dettmann, 1965 (equatorial focus).

Figure 10—*Aratrisporites flexibilis* Playford & Dettmann, 1965 (proximal focus).

Figure 11—*Aratrisporites flexibilis* Playford & Dettmann, 1965 (distal-equatorial focus, same specimen as Figure 10).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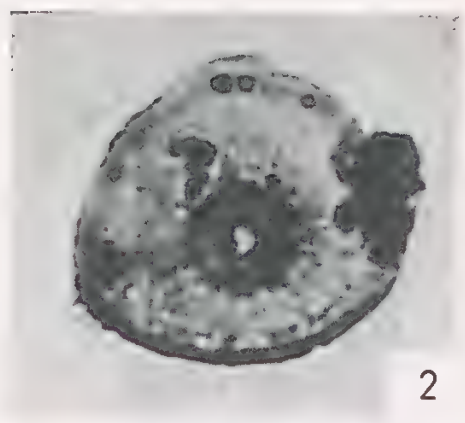
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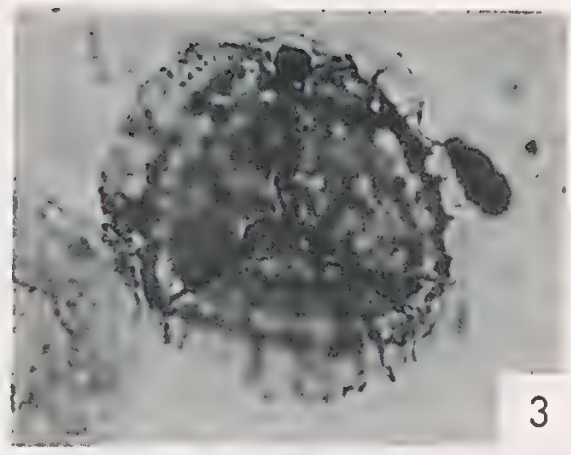
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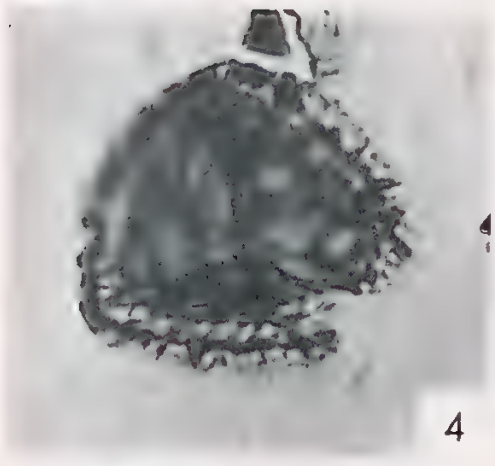
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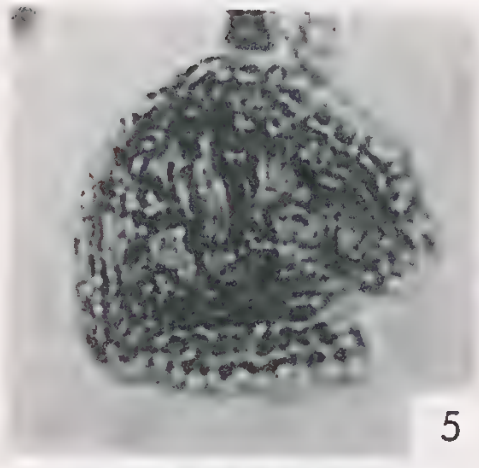
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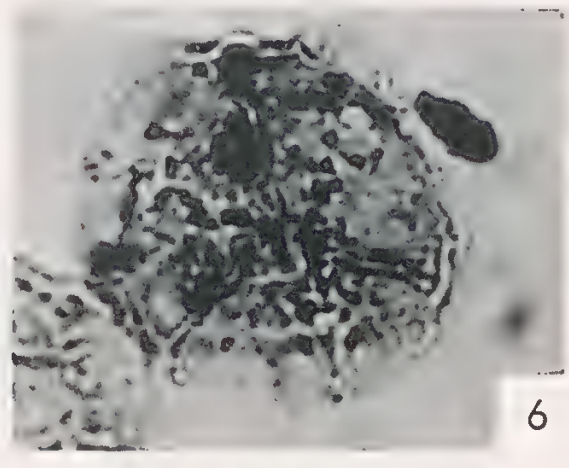
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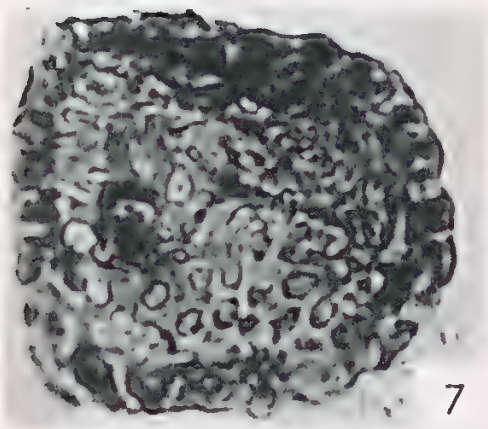
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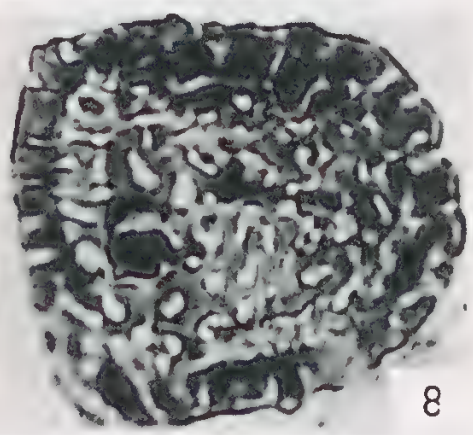
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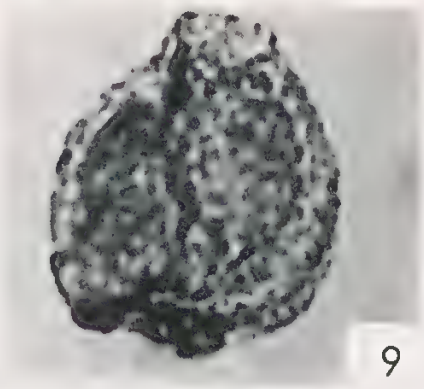
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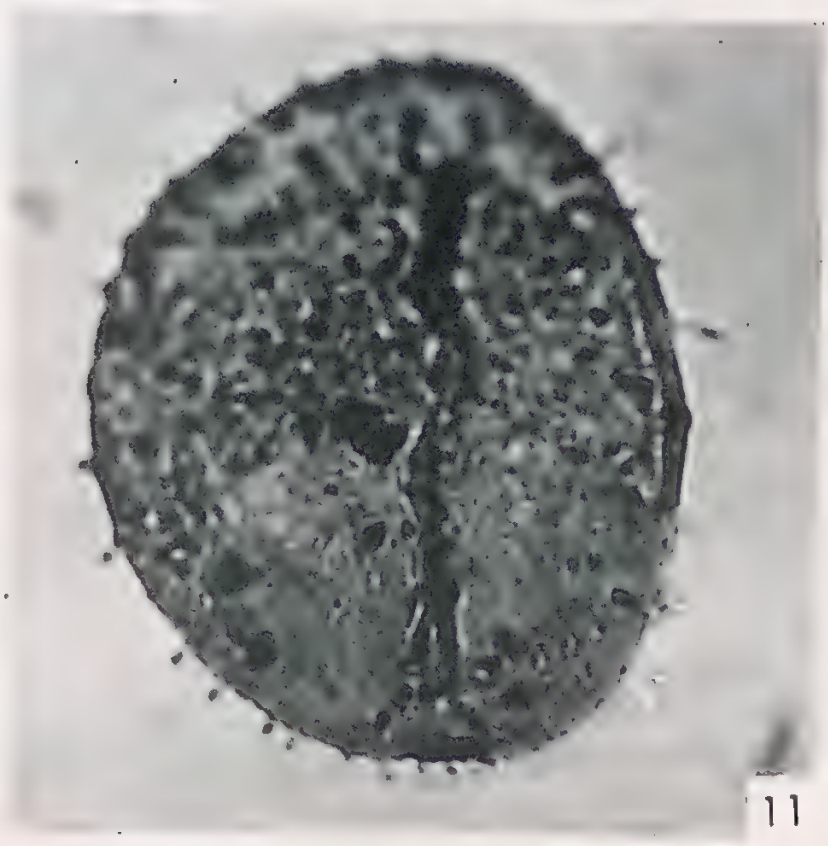
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PLATE 3

PLATE 4

(All photographs approximately × 1000, unless otherwise stated)

Figure 1—*Duplicisporites* sp. (median focus).

Figure 2—cf. *Discisporites psilatus* (de Jersey, 1964 (median focus).

Figure 3—*Aratrisporites* sp. cf. *A. paenulatus* Playford & Dettmann, 1965 (equatorial focus).

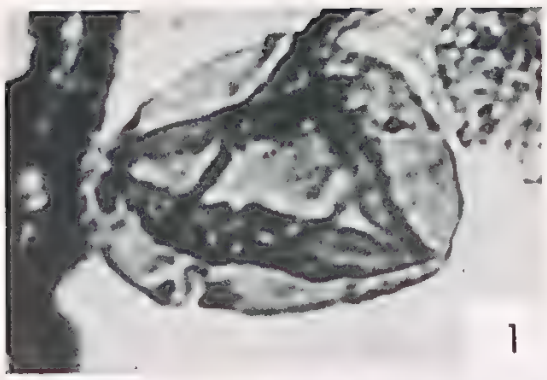
Figure 4—*Aratrisporites flexibilis* Playford & Dettmann, 1965 (equatorial focus).

Figure 5—*Grandispora* sp. A (equatorial focus).

Figure 6—*Hamiapollenites insculptus* Playford & Dettmann, 1965 (median focus, × 500).

Figure 7—*Aratrisporites parvispinosus* Leschik *emend.* Playford, 1965 (equatorial focus).

Figure 8—*Sulcosaccispora alaticonformis* (Malyavkina) de Jersey, 1968 (median focus).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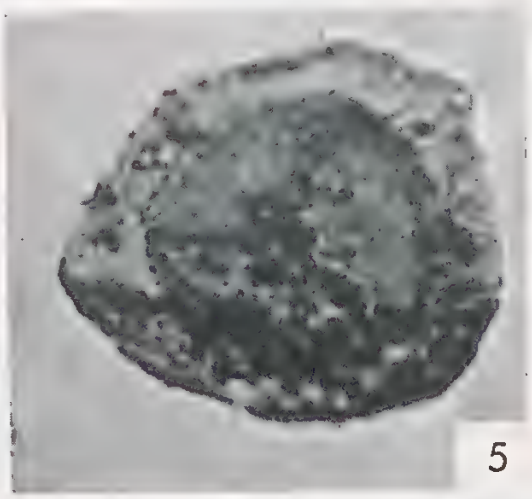
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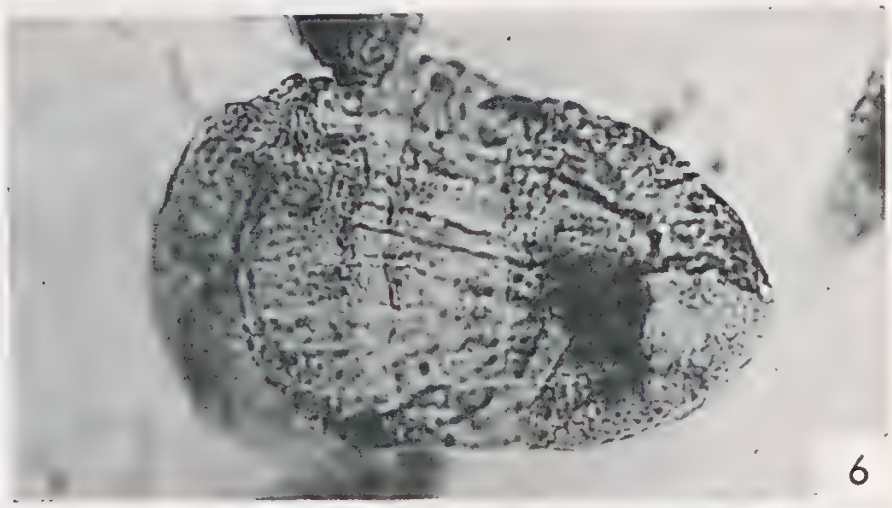
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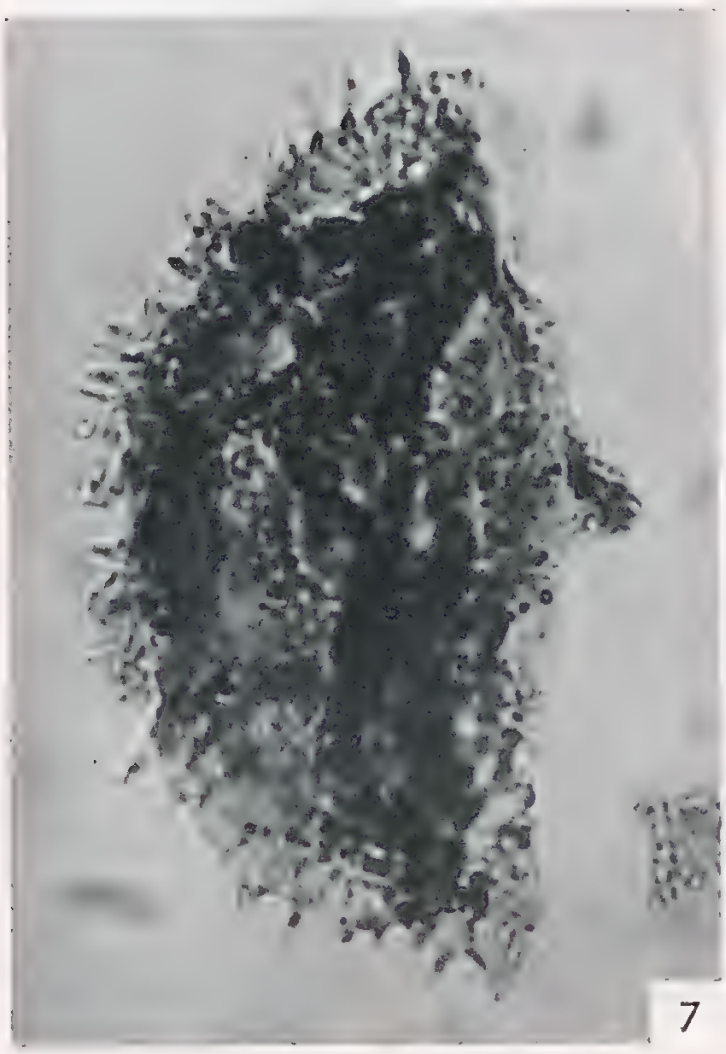
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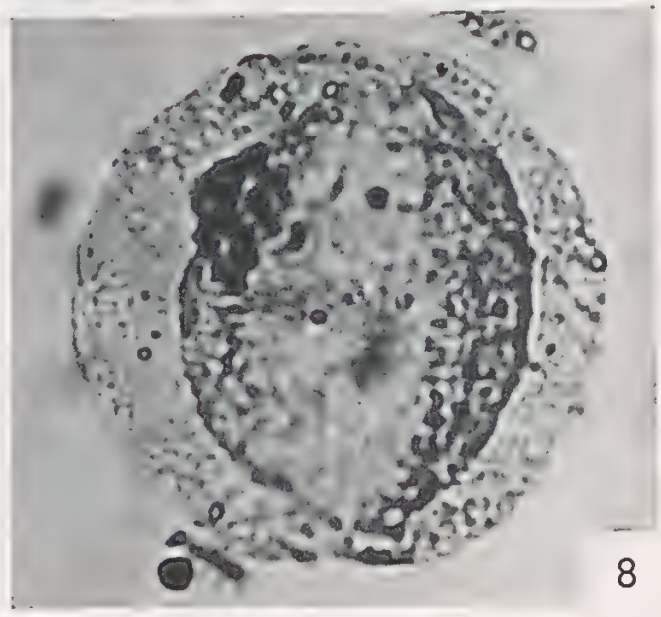
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PLATE 4

PLATE 5

(All photographs approximately × 1000, unless otherwise stated)

Figure 1—*Pilasporites crateraformis* Jain, 1968 (median focus).

Figure 2—*Cycadopites tivoliensis* sp. nov. (equatorial focus, × 1100).

Figure 3—*Cycadopites tivoliensis* sp. nov. (equatorial focus, × 1100).

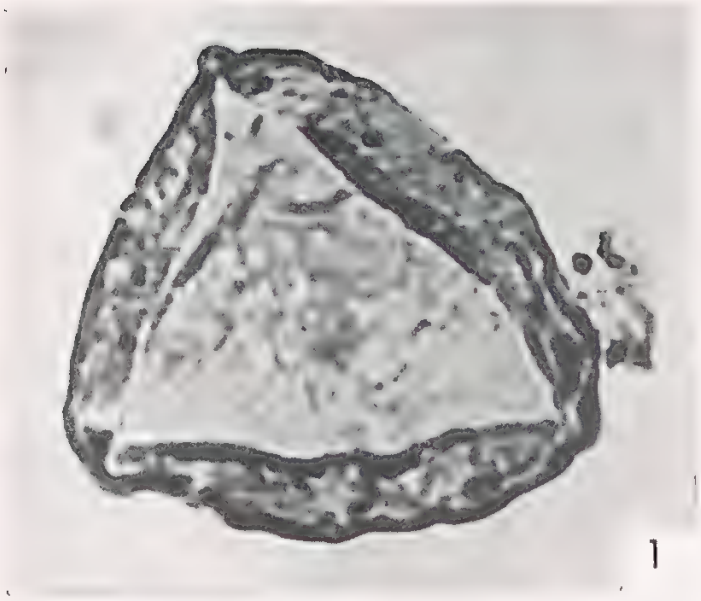
Figure 4—*Pilasporites crateraformis* Jain, 1968 (median focus).

Figure 5—*Cycadopites tivoliensis* sp. nov. (equatorial focus, portion of holotype showing fine conate sculpture, × 2000).

Figure 6—*Pilasporites crateraformis* Jain, 1968 (median focus).

Figure 7—*Equisetosporites* sp. (median focus, × 1100).

Figure 8—*Cycadopites tivoliensis* sp. nov. (Holotype, median focus, × 1100).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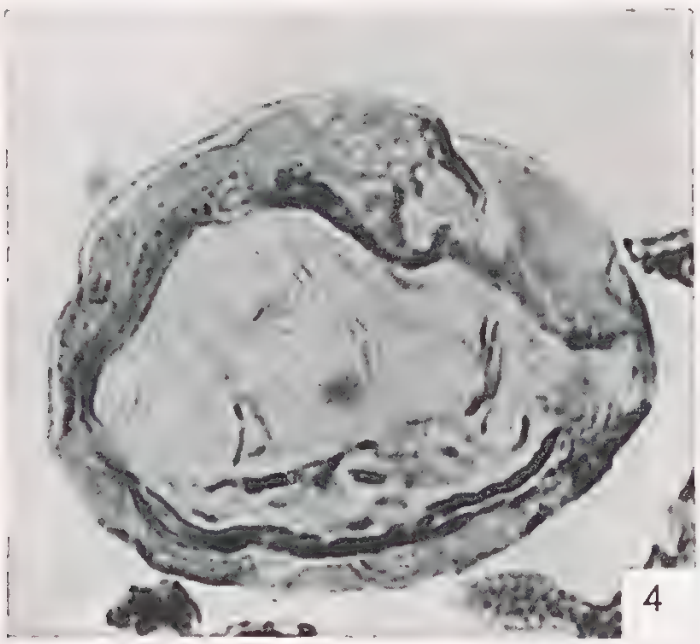
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PLATE 5

APPENIDIX—Lists of Microfloral Assemblages

The assemblages recorded below are arranged in ascending stratigraphic order for each of the boreholes studied. In the headings for the samples, depth, lithology, formation and number of specimens are recorded. Regarding the latter, the figures indicate that counts of these magnitudes were made; addition of the + sign, e.g. 200 +, indicates that an additional low power traverse was made of the available slides. Species recorded only in such additional traverses are indicated by the sign + in each list. Indeterminate specimens have not been included.

G.S..Q IPSWICH 16

KHOLO SUB-GROUP (MOUNT CROSBY FORMATION)

942ft. 5in.

Dark grey shale

Count 200+

Anapiculatisporites cf. *pristidentatus*	+
Anapiculatisporites sp. (indet.)	1.0%
cf. *Anapiculatisporites* sp.	0.5%
Annulispora folliculosa	+
Apiculatisporis sp. (indet.)	1.0%
Circulisporites parvus	1.0%
Clavatisporites cf. hammenii	+
Conaletes sp. (indet.)	0.5%
Conbaculatisporites cf. *mesozoicus*	0.5%
Craterisporites rotundus	1.0%
Cycadopites nitidus	17.5%
Densosporites raceviewensis	+
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	29.0%
Foveosporites sp.	0.5%
Grandispora sp. A.	+
Granulatisporites sp.	0.5%
Guthoerlisporites cancellosus	0.5%
cf. *Guttatisporites* sp.	0.5%
Inaperturopollenites sp. (indet.)	0.5%
Leiotriletes directus	5.5%
Lycopodiumsporites sp.	0.5%
Osmundacidites spp.	6.5%
Pustulatisporites blackstonensis	3.0%
Rewanispora foveolata	+
Stereisporites antiquasporites	+
Stereisporites perforatus	0.5%
Stereisporites sp. (indet.)	2.5%
Uvaesporites verrucosus	2.5%
Vitreisporites sp. (indet.)	0.5%
Disaccites (indet.)	23.5%

920ft. 6in.

Dark grey carb. siltstone

No count

Apiculatisporis sp. (indet.)
Aratrisporites sp. (indet.)
Cycadopites nitidus
Cycadopites tivoliensis
Duplexisporites problematicus
Leiotriletes directus
Osmundacidites sp. (indet.)
Polypodiisporites ipsviciensis
Pustulatisporites blackstonensis
Uvaesporites verrucosus
Disaccites (indet.)

902ft.

Dark grey carb. siltstone

No count

Cycadopites nitidus
Duplexisporites problematicus
Inaperturopollenites sp. (indet.)
Leiotriletes directus
Osmundacidites sp.
Stereisporites sp.
Uvaesporites verrucosus
Disaccites (indet.)

807ft. 7in.

Dark grey carb. shale

No count

Cycadopites nitidus
Dictyophyllidites mortoni
Duplexisporites problematicus
Leiotriletes directus
Osmundacidites sp.
Rewanispora foveolata
Uvaesporites verrucosus
Vitreisporites sp. (indet.)
Disaccites (indet.)

737ft.

Grey siltstone

No count

Conaletes sp.
Cycadopites nitidus
Duplexisporites problematicus
Leiotriletes directus
Osmundacidites sp.
Polypodiisporites ipsviciensis
Uvaesporites verrucosus
Disaccites (indet.)

724ft. 11in.

Dark grey carb. shale

No count

Cycadopites nitidus
Duplexisporites problematicus

KHOLO SUB-GROUP (HECTOR TUFF)

259ft. 2in.

Grey carb. mudstone

No count

Araucariacites sp.
Dictyophyllidites cf. *harrisii*
Duplexisporites problematicus
Osmundacidites sp.
Rewanispora foveolata
Stereisporites antiquasporites
Disaccites (indet.)

215ft. 2 in.

No count

Inaperturopollentes sp.
Disaccites (indet.)

TIVOLI FORMATION

37ft. 2in.

Grey carb. shale

Count 100+

Apiculatisporis globosus	+
cf. *Conaletes* sp.	1%
Converrucosisporites cameroni	3%

Cycadopites nitidus	17%
Duplexisporites problematicus	66%
Granulatisporites sp. (indet.)	2%
Inaperturopollenites spp. (indet.)	4%
Leiotriletes directus	2%
Polypodiisporites ipsviciensis	1%
Stereisporites antiquasporites	+
Uvaesporites verrucosus	1%
Disaccites (indet.)	3%

N.S. 566 (IPSWICH)

KHOLO SUB-GROUP (COLLEGES CONGLOMERATE)

2090ft. 10in.

Grey carb. shale

No count

Cycadopites nitidus
Duplexisporites problematicus
Inaperturopollenites cf. *fuscus*
Osmundacidites sp.
Polypodiisporites ipsviciensis
Punctatosporites sp.
cf. *Rugulatisporites* sp.
Disaccites (indet.)

2010ft.

Black carb. shale

Count 100+

Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Apiculatisporis sp. (indet.)	1%
cf. *Apiculatisporis* sp.	1%
Aratrisporites cf. *granulatus*	+
Aratrisporites sp. (indet.)	+
Calamospora cf. *tener*	+
Conaletes spp.	2%
Converrucosisporites cameroni	3%
Converrucosisporites sp. (indet.)	1%
Craterisporites rotundus	1%
Cycadopites crassimarginis	+
Cycadopites granulatus	1%
Cycadopites nitidus	8%
Cycadopites sp. (indet.)	2%
cf. *Cycadopites* sp.	1%
Dictyophyllides mortoni	+
Duplexisporites problematicus	4%
Equisetosporites sp.	+
Foveosporites sp. (indet.)	2%
Grandispora sp. A	1%
Granulatisporites sp. (indet.)	1%
Guttatisporites spp. (indet.)	+
Inaperturopollenites sp. (indet.)	+
Leiotriletes directus	5%
Lophotriletes sp. (indet.)	+
Osmundacidites wellmanii	+
Osmundacidites sp. (indet.)	2%
Pilasporites crateraformis	1%
cf. *Pilasporites* sp.	+
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	2%
Stereisporites antiquasporites	+
Uvaesporites verrucosus	2%
Disaccites (indet.)	59%

KHOLO SUB-GROUP (HECTOR TUFF)

1931ft. 6in.

Grey carb. shale

No count

Craterisporites rotundus
Dictyophyllidites mortoni
Duplexisporites problematicus
Leiotriletes directus
Osmundacidites sp.
Rewanispora foveolata
Stereisporites sp.
Disaccites (indet.)

1832ft. 2in.

Grey shale

No count

Apiculatisporis cf. *globosus*
Baculatisporites comaumensis
Duplexisporites problematicus
Inaperturopollenites sp. (indet.)
Disaccites (indet.)

TIVOLI FORMATION

1706ft. 6in.

Grey carb. sale

No count

Apiculatisporis globosus
Converrucosisporites cameroni
Cycadopites nitidus
Cycadopites sp. (indet.)
Dictyophyllidites mortoni
Duplexisporites problematicus
Inaperturopollenites sp. (indet.)
Osmundacidites sp. (indet.)
Polypodiisporites ipsviciensis
Rewanispora foveolata
Stereisporites antiquasporites
Stereisporites sp. (indet.)
Disaccites (indet.)

1619ft. 1in.

Grey carb. shale

Count 100+

Anapiculatisporites pristidentatus	+
Aratrisporites parvispinosus	+
Clavatisporites cf. *hammenii*	+
Conbaculatisporites cf. *mesozoicus*	1%
Cycadopites granulatus	1%
Cycadopites nitidus	8%
Densosporites raceviewensis	+5%
Duplexisporites problematicus	57%
Grandispora sp.	1%
Guthoerlisporites canellosus	+
Inaperturopollenites sp. (indet.)	1%
Leiotriletes directus	2%
Osmundacidites spp.	4%
Pilasporites crateraformis	+
Pustulatisporites blackstonensis	+
Rewanispora foveolata	+
Stereisporites antiquasporites	+
Uvaesporites verrucosus	2%
Vitreisporites sp. (indet.)	+
Disaccites (indet.)	23%

1573ft. 8in.

Grey carb. shale

No count

Annulispora microannulata
Apiculatisporis cf. *globosus*
Apiculatisporis sp. (indet.)
Aratrisporites sp. (indet.)
Baculatisporites comaumensis
Converrucosisporites cameroni
Craterisporites rotundus
Cycadopites nitidus
Duplexisporites problematicus
Leiotriletes directus
Nevraistrickia taylorii

Rewanispora foveolata
Stereisporites antiquasporites
Disaccites (indet.)

1519ft. 7in.

Grey carb. shale

Count 200+

Anapiculatisporites pristidentatus	1.0%
Aratrisporites banksi	+
Araucariacites sp. (indet.)	0.5%
Craterisporites rotundus	1.0%
Cycadopites nitidus	1.5%
Cycadopites tivoliensis	%
Cycadopites sp. (indet.)	0.5%
Duplexisporites problematicus	28.0%
Granulatisporites spp.	1.0%
Inaperturopollenites spp.	1.5%
Leiotriletes directus	5.5%
Osmundacidites spp.	2.5%
Pilasporites crateraformis	1%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	0.5%
Pustulatisporites blackstonensis	1.0%
Rewanispora foveolata	4.5%
Stereisporites antiquasporites	0.5%
Stereisporites sp. (indet.)	1.0%
Uvaesporites verrucosus	1.5%
Verrucosisporites spp.	3.5%
Disaccites (indet.)	44.5%

1487ft. 1in.

Grey shale and siltstone

No count

Baculatisporites comaumensis
Clavatisporites cf. *hammenii*
Converrucosisporites cameroni
Craterisporites rotundus
Cycadopites nitidus
Duplexisporites problematicus
Inaperturopollenites sp. (indet.)
Leiotriletes directus
Rewanispora foveolata
Stereisporites antiquasporites
Disaccites (indet.)

1395ft. 11in.

Grey carb. shale

Count 200+

Acanthotriletes bradiensis	+
Apiculatisporis globosus	0.5%
Apiculatisporis sp. (indet.)	0.5%
Araucariacites sp. (indet.)	0.5%
Chordasporites australiensis	0.5%
Cycadopites nitidus	1.0%
Cycadopites tivoliensis	0.5%
Cycadopites sp. (indet.)	0.5%
Duplexisporites problematicus	1.5%
Hamiapollenites insculptus	0.5%
Inaperturopollenites spp.	1.0%
Osmundacidites sp.	0.5%
Pilasporites crateraformis	0.5%
Platysaccus queenslandi	0.5%
Stereisporites antiquasporites	+
Verrucosisporites sp.	1.0%
Disaccites (indet.)	90.5%

1310ft. 7in.

Black carb. shale

No count

Apiculatisporis sp. (indet.)
Clavatisporites cf. *hammenii*
Conaletes sp. (indet.)
Converrucosisporites cameroni
Cycadopites nitidus
Dictyophyllidites mortoni
Duplexisporites problematicus
Granulatisporites sp.
Inaperturopollenites sp.
Neoraistrickia taylorii
Osmundacidites sp.
Polycingulatisporites densatus
Disaccites (indet.)

1074ft.

Grey shale

No count

Anapiculatisporites pristidentatus
Annulispora folliculosa
Converrucosisporites cameroni
Craterisporites rotundus
Duplexisporites problematicus
Pustulatisporites blackstonensis
Disaccites (indet.)

1056ft. 4in.

Grey carb. shale

Count 100+

Annulispora microannulata	+
Apiculatisporis cf. *globosus*	1%
Apiculatisporis sp. (indet.)	1%
Cycadopites nitidus	3%
Cycadopites tivoliensis	1%
Cycadopites sp. (indet.)	+
Dictyophyllidites mortoni	1%
Duplexisporites problematicus	17%
Grandispora sp. A	+
Inaperturopollenites sp. (indet.)	1%
Leiotriletes directus	3%
Osmundacidites sp. (indet.)	2%
Pilasporites craterformis	1%
Polypodiisporites ipsviciensis	1%
Uvaesporites verrucosus	2%
Vitreisporites pallidus	1%
Disaccites (indet.)	65%

983ft.

Grey shale

Count 200+

Annulispora folliculosa	0.5%
Apiculatisporis globosus	0.5%
Apiculatisporis sp. (indet.)	1.5%
Aratrisporites flexibilis	0.5%
Clavatisporites cf. *hammenii*	0.5%
Conbaculatisporites sp. (indet.)	0.5%
Converrucosisporites sp. (indet.)	0.5%
Craterisporites rotundus	0.5%
Cycadopites nitidus	4.5%
Cycadopites tivoliensis	+
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	19.0%
Granulatisporites spp.	3.0%
Inaperturopollenites spp.	3.5%
Leiotriletes directus	2.0%
Osmundacidites spp.	5.5%
Pilasporites crateraformis	+
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	1.5%
Punctatosporites walkomi	0.5%
Stereisporites antiquasporites	0.5%
Uvaesporites verrucosus	1.0%
Vitreisporites pallidus	0.5%
Disaccites (indet.)	52.2%

980ft. 4in.

Grey carb. shale

Count 200+

Anapiculatisporites sp.	+
Apiculatisporis globosus	1.0%
Apiculatisporis spp. (indet.)	15.0%
Araucariacites sp.	0.5%
Calamospora tener	0.5%
Conaletes spp.	1.5%
Converricosisporites cameroni	4.0%
Craterisporites rotundus	1.0%
Cycadopites nitidus	0.5%
Dictyophyllidites mortoni	+
Duplexisporites problematicus	25.0%
Granulatisporites spp.	5.5%
Inaperturopollenites spp.	1.0%
Leiotriletes directus	5.0%
Lophotriletes sp.	0.5%
Lycospora pallida	+
Neoraistrickia taylorii	1.0%
Osmundacidites spp.	11.5%
Polypodiisporites ipsviciensis	11.5%
Punctatosporites walkomi	6.5%
Stereisporites antiquasporites	+
Tuberculatisporites aberdarensis	13.5%
Disaccites (indet.)	1.0%

899ft. 7in.

Grey carb. shale

Count 200+

Anapiculatisporites pristidentatus	+
Apiculatisporis sp. (indet.)	0.5%
Aratrisporites cf. *granulatus*	+
Aratrisporites sp. (indet.)	+
Clavatisporites cf. *hammenii*	+
Conbaculatisporites cf. *mesozoicus*	0.5%
Craterisporites rotundus	0.5%
Cycadopites granulatus	+
Cycadopites nitidus	2.5%
Cycadopites tivoliensis	1.0%
Cycadopites sp. (indet.)	+
Duplexisporites problematicus	8.0%
Duplicisporites sp.	+
Granulatisporites sp.	0.5%
Guthoerlisporites cancellosus	+
Inaperturopollenites sp.	0.5%
Neoraistrickia taylorii	+
Osmundacidites wellmanii	0.5%
Osmundacidites spp. (indet.)	40.5%
Pilasporites crateraformis	+
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	0.5%
Pustulatisporites blackstonensis	+
Rewanispora foveolata	+
Rugulatisporites sp.	+
Stereisporites antiquasporites	+
Uvaesporites verrucosus	+
Disaccites (indet.)	44.5%

789ft. 4in.

Grey shale

Count 200+

Anapiculatisporites pristidentatus	+
Anapiculatisporites sp. (indet.)	+
cf. *Anapiculatisporites* sp.	+
Annulispora folliculosa	+
Annulispora microannulata	+
Apiculatisporis globosus	+
Apiculatisporis sp. (indet.)	1.5%
Aratrisporites cf. *granulatus*	+
Baculatisporites comaumensis	0.5%
Cadargasporites baculatus	+
Chordasporites australiensis	+
Conaletes sp.	0.5%
Conbaculatisporites cf. *mesozoicus*	+
Converrucosisporites cf. *cameroni*	+
Craterisporites rotundus	1.0%
Cycadopites nitidus	3.5%
Cycadopites tivoliensis	+
Dictyophyllidites mortoni	+
Duplexisporites problematicus	7.5%
Grandispora sp. A	+
Granulatisporites sp.	0.5%
cf. *Grebespora* sp.	0.5%
Leiotriletes directus	2.0%
Lophotriletes sp.	0.5%
Lycospora pallida	+
Osmundacidites wellmanii	0.5%
Osmundacidites sp. (indet.)	0.5%
Pilasporites crateraformis	0.5%
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	3.0%
Punctatosporites walkomi	0.5%
Pustulatisporites blackstonensis	+
Pustulatisporites cf. *blackstonensis*	+
Rewanispora foveolata	1.5%
Rugulatisporites sp.	0.5%
Stereisporites antiquasporites	0.5%
Stereisporites perforatus	+
Stereisporites sp. (indet.)	1.0%
Tuberculatosporites aberdarensis	0.5%
Uvaesporites verrucosus	1.5%
Verrucosisporites spp.	1.0%
Vitreisporites pallidus	0.5%
Vitreisporites sp. (indet.)	1.0%
Disaccites (indet.)	68.5%

678ft.

Grey shale

Count 200+

Anapiculatisporites pristidentatus	+
Annulispora microannulata	0.5%
Apiculatisporis globosus	0.5%
Apiculatisporis sp. (indet.)	1.0%
Araucariacites sp.	0.5%
Conaletes sp.	0.5%
Conbaculatisporites cf. *mesozoicus*	1.5%
Craterisporites rotundus	0.5%
Cycadopites nitidus	1.0%
Cycadopites tivoliensis	+
Dictyophyllidites mortoni	+
Duplexisporites problematicus	75.0%
Granulatisporites spp.	1.5%
Inaperturopollenites sp.	1.0%
Leiotriletes directus	2.0%
Lophotriletes sp.	0.5%
Neoraistrickia taylorii	0.5%
Osmundacidites spp.	2.5%
Polypodiisporites ipsviciensis	1.0%
Rewanispora foveolata	0.5%
Stereisporites antiquasporites	+
Stereisporites perforatus	+
Uvaesporites verrucosus	3.5%
Verrucosisporites sp.	0.5%
Disaccites (indet.)	5.5%

597ft. 9in.

Black shale

Count 200+

Acanthotriletes bradiensis	+
Anapiculatisporites cf. *pristidentatus*	+
Annulispora microannulata	0.5%
Apiculatisporis globosus	+
Aratrisporites flexibilis	+
Aratrisporites cf. *paenulatus*	+
Cadargasporites baculatus	0.5%
Calamospora tener	0.5%
Chordasporites australiensis	+
Circulisporites parvus	1.0%
Conbaculatisporites cf. *mesozoicus*	+
Conbaculatisporites sp. (indet.)	+
Converrucosisporites cameroni	1.0%
Cycadopites granulatus	1.5%
Cycadopites nitidus	6.5%
Cycadopites tivoliensis	+
Cycadopites spp. (indet.)	1.0%

cf. *Densoisporites* sp.	+
Dictyophyllidites mortoni	1.0%
cf. *Discisporites psilatus*	+
Duplexisporites problematicus	+
Grandispora sp. A	+
Granulatisporites sp. (indet.)	3.0%
Guthoerlisporites cancellosus	+
Hamiapollenites insculptus	+
Inaperturopollenites spp.	2.0%
Leiotriletes directus	3.0%
Lophotriletes sp. (indet.)	1.5%
Lycospora pallida	+
Neoraistrickia taylorii	1.5%
Osmundacidites wellmanii	0.5%
Osmundacidites sp. (indet.)	0.5%
Pilasporites crateraformis	+
Platysaccus queenslandi	1.0%
Polypodiisporites ipsviciensis	2.5%
Semiretisporis denmeadi	+
Stereisporites antiquasporites	0.5%
Stereisporites perforatus	+
Stereisporites sp. (indet.)	+
Sulcosaccispora alaticonformis	+
Tuberculatosporites aberdarensis	15.0%
Uvaesporites verrucosus	+
Verrucosisporites sp.	0.5%
Vitreisporites pallidus	4.0%
Vitreisporites sp. (indet.)	0.5%
Disaccites (indet.)	49.5%

523ft. 1in.

Grey carb. shale

Count 200+

Annulispora microannulata	+
Apiculatisporis globosus	1.5%
Apiculatisporis sp. (indet.)	0.5%
Chordasporites australiensis	0.5%
Clavatisporites cf. *hammenii*	+
Conaletes sp.	1.5%
Conbaculatisporites cf. mesozoicus	1.0%
Craterisporites rotundus	+
Cycadopites crassimarginis	0.5%
Cycadopites nitidus	5.0%
Cycadopites tivoliensis	+
Dictyophyllidites mortoni	1.0%
Duplexisporites problematicus	9.5%
Granulatisporites sp.	0.5%
Inaperturopollenites sp. (indet.)	3.0%
Leiotriletes directus	1.5%
Lophotriletes sp.	1.0%
Osmundacidites spp.	2.5%
Pilasporites crateraformis	+
Polypodiisporites ipsviciensis	0.5%
Pustulatisporites blackstonensis	+
Rewanispora foveolata	+
Tuberculatosporites aberdarensis	1.0%
Uvaesporites verrucosus	+
Disaccites (indet.)	69.0%

COONEANA FORMATION

395ft. 8in.

Grey carb. shale

Count 200+

Anapiculatisporites pristidentatus	+
Annulispora folliculosa	+
Annulispora microannulata	+
Apiculatisporis globosus	1.5%
Aratrisporites banksi	+
Araucariacites sp. (indet.)	0.5%
Clavatisporites cf. *hammenii*	+
Conaletes spp. (indet.)	2.0%
Conbaculatisporites cf. *mesozoicus*	+
Conbaculatisporites sp. (indet.)	+
Craterisporites rotundus	+
Cycadopites nitidus	0.5%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	+
Duplexisporites problematicus	0.5%
Foveosporites sp.	+
Gathoerlisporites cancellosus	+
Inaperturopollenites sp.	+
Leiotriletes directus	1.5%
Neoraistrickia taylorii	+
Osmundacidites sp.	+
Pilasporites crateraformis	0.5%
Platysaccus queenslandi	0.5%
Pustulatisporites blackstonensis	+
Rewanispora foveolata	+
Stereisporites antiquasporites	+
Stereisporites perforatus	+
Tuberculatosporites aberdarensis	2.0%
Uvaesporites verrucosus	+
Vitereisporites pallidus	2.5%
Disaccites (indet.)	87.5%

385ft. 5in.

Grey carb. shale

Count 200+

Annulispora microannulata	+
Apiculatisporis globosus	+
Apiculatisporis sp. (indet.)	0.5%
Aratrisporites banksi	+
Aratrisporites flexibilis	+
Aratrisporites parvispinosus	1.0%
Clavatisporites cf. *hammenii*	+
Conbaculatisporites cf. *mesozoicus*	+
Craterisporites rotundus	+
Cycadopites nitidus	1.5%
Cycadopites sp. (indet.)	+
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	0.5%
Grandispora sp. A	+
Granulatisporites sp.	0.5%
Guthoerlisporites cancellosus	+
Inaperturopollenites spp.	3.5%
Leiotriletes directus	1.0%
Osmundacidites spp.	2.5%
Pilasporites crateraformis	0.5%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	3.0%
Punctatosporites walkomi	0.5%
Rewanispora foveolata	+
Semiretisporis denmeadi	+
Stereisporites antiquasporites	+
Stereisporites perforatus	+
Stereisporites sp. (indet.)	0.5%
Uvaesporites verrucosus	0.5%
Vitreisporites pallidus	0.5%
Disaccites (indet.)	83.0%
Gen. nov. A	+

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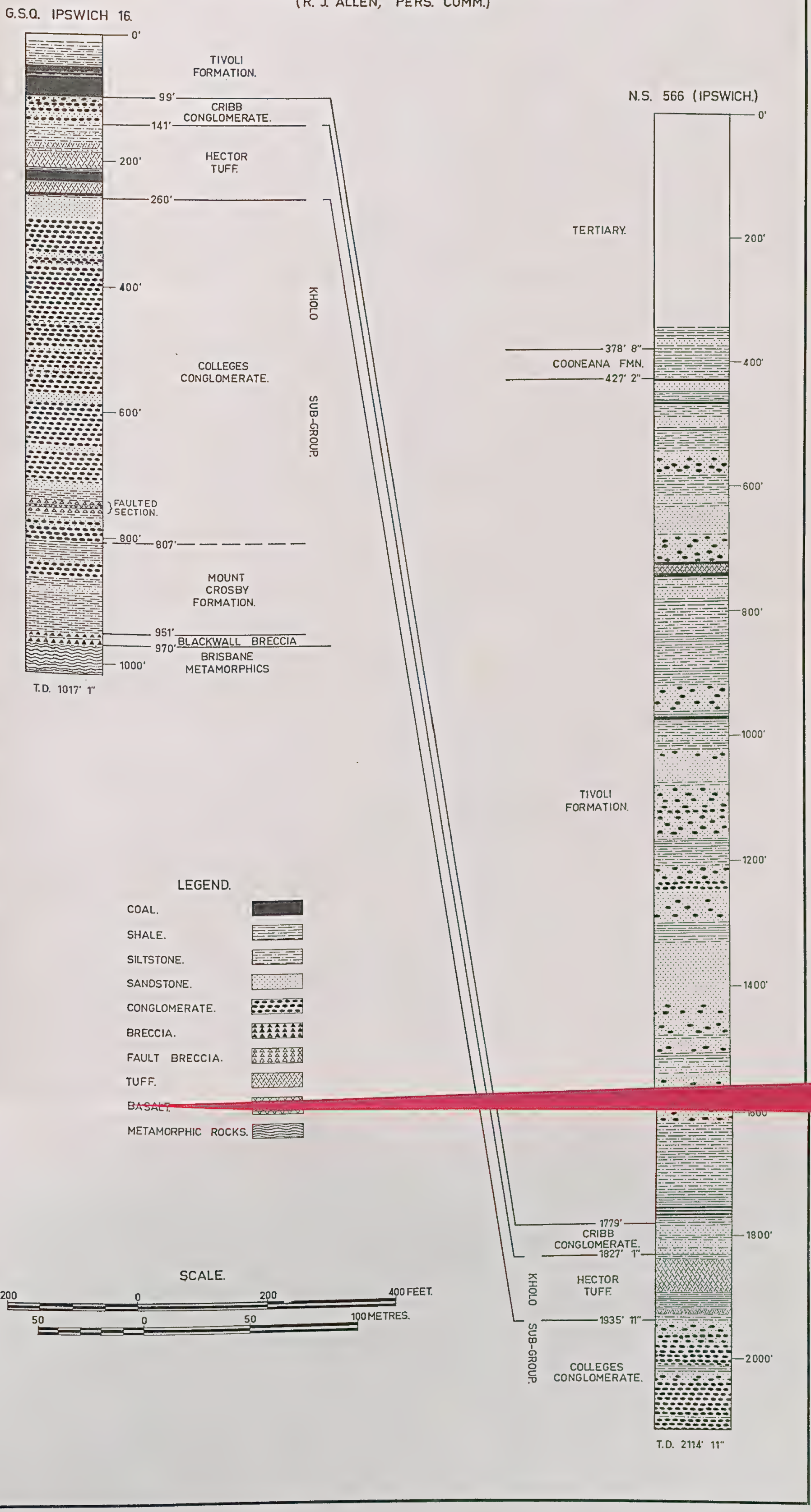
FIG. 2: DIAGRAM SHOWING LITHOLOGICAL CORRELATION OF G.S.Q. IPSWICH 16 AND N.S. 566 (IPSWICH)

(R. J. ALLEN, PERS. COMM.)



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DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

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REDESCRIPTION OF FENESTELLID SPECIES FROM THE UPPER CARBONIFEROUS OF EASTERN AUSTRALIA

by
P. J. G. FLEMING
Geological Survey of Queensland

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SUMMARY

Species of *Fenestella* and *Polypora* from the Upper Carboniferous of Queensland and New South Wales are redescribed, the types and other material illustrated by photographs, and the stratigraphic ranges of the species recorded. One of the Fenestellas is a representative of *F.* (*Bajoola*) Fleming, 1966. Two species are assigned only provisionally to *Polypora* McCoy, 1844. Species described are *Fenestella micropora* (Crockford), *F. osbornei* (Crockford) *F. malchi* (Crockford), *F.* (*Bajoola*) *cincta* (Crockford), *Polypora neerkolensis* Crockford, *"Polypora" pustulosa* (Crockford), and *"Polypora" palenensis* (Crockford). *Polypora tenuirama* (Crockford) is regarded as a synonym of *"P". pustulosa.* There is a previously unrecognized strong similarity between the fenestellid faunas of the Upper Carboniferous of Queensland and New South Wales. All species described in this paper, except *F. malchi* which may be conspecific with *F. cerva* Campbell from New South Wales, are represented in the Upper Carboniferous of New South Wales.

INTRODUCTION

Fenestellids are very abundant in the Upper Carboniferous of Queensland, but only comparatively small collections have been made, and only one paper, by Crockford (1949), has been devoted to descriptions of them. The species names given by Crockford were—

Fenestrellina malchi
F. osbornei
F. micropora
F. cincta
F. rectangularis
Polypora pustulosa
P. neerkolensis
P. palenensis
P. tenuirama

The types of all but the second species are from the Mount Barney beds and the Neerkol Formation, Queensland. The type of *F. osbornei* is from Stroud, New South Wales. Crockford followed Bassler (1935) in the use of the name *Fenestrellina* for forms now properly designated *Fenestella.*

Crockford's paper was not illustrated by photographs, and there are other difficulties in applying the names. For example, many of the types are poorly preserved, one is lost, and the descriptions emphasized measurements rather than surface ornament and other features readily observable in good material.

Maxwell (1964) related these and other species to stratigraphic levels, but did not publish full redescriptions of the species. The fenestellids are useful stratigraphically, because of their abundance in the Upper Carboniferous, even where other fossils are rare.

Fleming (1967) defined the Neerkol Formation and listed the faunal assemblages. Campbell (1961, 1962) described and recorded several forms from New South Wales including some of Crockford's species, though he did not examine the type material of these. It appeared that there was marked dissimilarity between the fenestellid faunas of the two States, since Campbell recognized only a few species in common. A re-assessment of the Queensland species shows, though, that there is a greater similarity than at first appeared.

All Crockford's type specimens are in hard, silicified mudstone, most are moulds, and few show any internal structure. The types and other material have been examined mainly with the aid of latex casts. Boiling in dilute strong acids removes iron oxides which have replaced the leached skeletons in most of the moulds. A surprising amount of internal structure can be seen in good moulds. Very fine sediment often fills zooecia and other openings perfectly, and in these cases, boiling in dilute acid followed by a dissection process reveals the structure.

Material.—All of the holotypes except those of *osbornei* and *cincta* are housed in the Geology Department, University of Queensland. The type of *F.* (*Bajoola*) *cincta* has not been located, and a neotype is chosen in this paper. The type of *F. osbornei* is in the Geology Department, University of Sydney. Specimens held in the University of Sydney still bear the numbers by which they were mentioned in the original publication by Crockford. Those housed in the University of Queensland have received new numbers since 1949. In this paper, in sections in the systematic descriptions marked "material", the numbers and locations of the holotypes are given, as well as the new University of Queensland numbers for the specimens described by Crockford. There are some numbering errors in the University of Queensland collection, and these are recorded or corrected as far as the information with the specimens allows. Numbers of some new, well preserved topotypes held either at the University of Queensland or at the Geological Survey of Queensland are given. Specimens

are referred to by F. numbers (fossil collection numbers) prefixed by the designation UQ (University of Queensland), GSQ (Geological Survey of Queensland), and US (University of Sydney). The micrometric formula given with the species descriptions records the number of branches in 10 mm, dissepiments in 10 mm, apertures per row per 5 mm, nodes in 5 mm, width of branches, diameter of apertures, and number of apertures per row per fenestrule.

Acknowledgements.—Some of this work was done in 1960–61 at the University of Queensland. My thanks are due to Professor D. Hill for her kind permission to borrow types, and for her helpful advice during this period of work at the University; to Professor G. Philip and Dr. A. E. H. Pedder then of the University of New England, New South Wales, who made it possible for me to examine Dr. Campbell's type material; and to Dr. Dulhunty of the Geology Department, University of Sydney, for the loan of the type of *Fenestella osbornei* and the opportunity to examine other specimens in his care. Dr. Crockford assisted in the effort to locate the holotype of *Fenestella cincta.*

SYSTEMATIC DESCRIPTIONS

Family FENESTELLIDAE King, 1850

Genus *Fenestella* Lonsdale, 1839

Type species.—*Fenestella subantiqua* d'Orbigny, 1850. Wenlockian, England.

Subgenus *Fenestella* s. str.

Fenestella micropora (Crockford, 1949)

Pl. 1, figs 1–4

1949 *Fenestrellina micropora* Crockford, p. 424, fig. 3.
1961 *Fenestella micropora* (Crockford). Campbell, p. 461, pl. 63, figs 2a–c.
1964 *Fenestella micropora* (Crockford). Maxwell, p. 38, pl. 12, fig. 14.
1964 *Fenestella micropora* (Crockford). In Hill, D., and Woods, J. T. eds, pl. C III, figs 5–6.

Material.—Holotype UQF24944a, b, from 233817 Ridgelands 1 mile sheet area, ridge south of Lion Creek, central Queensland GSQ 999. Paratype UQF24945a, b, on same rock fragments as the holotype. Topotypes GSQF10911–10914.

Description.—Holotype a fragment about 6 mm square, poorly preserved in a fine grained sandstone, showing little surface detail. Shape of fragment, frequency of bifurcation of branches and number of supporting pillars on reverses of branches suggest that it is from proximal part of zoarium. Meshwork of species fine and regular. Branches 0·2 to 0·28 mm wide. Obverse surface with low, but wide, regular, very straight carina about 0·04 mm wide. Apertural branch surfaces depressed a little between apertures, not ornamented. Nodes on carina 0·3 to 0·4 mm, apart, strongly developed, regularly spaced, and with elongate bases. Apertures 0·08 to 0·1 mm in diameter, usually 0·28 mm, apart. Peristomes thin, not prominent, projecting obliquely away from carina, but not encroaching on fenestrules. Apertures not stabilized next to dissepiments; 2 to 3 apertures per row per fenestrule. Some apertures have about 8 apertural septa, but they are rather weak and seldom preserved. Fenestrules up to 0·35 mm wide, rounded at ends. Dissepiments about 0·06 mm wide in the centre, depressed below obverse branch surface. Branches and dissepiments finely striated on reverse. Rod-shaped structures project from the reverse of several branches of the holotype and are about 0·20 mm in diameter; set very near and below branch bifurcations and appear to be supporting pillars. Zooecia with hemi-hexagonal base shape. Bases up to about 0·4 mm long and half as wide.

MICROMETRIC FORMULA:

B/10	D/10	Z/5	N/5	BW	ZD	Z/F
15–19	12	19	12–15	0·4	0·08	2–3

Remarks.—*Fenestella micropora* is an easily recognized species. Its fineness, regularity of mesh, strong straight carina and strong, evenly spaced nodes are characteristic. The lateral carinae, which Campbell (1961) described as forming longitudinal channels in which the apertures lie, may be the result of crushing. The best preserved topotypes do not seem to be squashed appreciably and have convex obverse branch surfaces. The channels occur in many Queensland specimens, but usually in those preserved in incompetent types of rocks. It is noteworthy that the species has apertural septa as in *"Polypora" pustulosa* (q.v.), but they are not as well developed and not as frequently preserved.

Fenestella stellaris Campbell, 1961, is very similar to *F. micropora,* but comparison is made rather difficult by crowding of hemispherical pits on the branches of *stellaris.* It is possible that Campbell's species is *F. micropora* with ovicells.

This seems to be a long ranging species, extending through most of the Upper Carboniferous. Maxwell (1964) remarked that more intensive examination of the specimens he had interpreted as *F. micropora* might permit division into several species. However, specimens from all levels in the Upper Carboniferous are remarkably uniform in character.

Fenestella loganensis Wass, 1966

Pl. 1, figs 5, 6

1944 Non *Fenestella rectangularis* Condra and Elias, p. 104, pl. 22, figs 1–2.
1949 *Fenestrellina rectangularis* Crockford, p. 425, fig. 7.
1961 *Fenestella rectangularis* (Crockford). Campbell, p. 459, pl. 57, figs 1a–c.
1964 *Fenestella rectangularis* (Crockford). Maxwell, p. 38, pl. 12, figs 11–12.
1966 *Fenestella loganensis* Wass. nom. nov. for *F. rectangularis* Crockford.

Material.—Holotype UQF2499A from Por. 193 or 194, Par. Palen, Mount Barney area, south-east Queensland. Paratypes, UQF25000 and 25003 from the type locality; UQF24969 from Malchi Creek, Neerkol, central Queensland. Topotypes GSQF-10908, 10926, 10937, from Malchi Creek, Ridgelands 1–mile sheet area 265791.

Description.—Holotype about 12 mm long and 10 mm wide, probably from the mature stage of a zoarium, rather crushed but otherwise reasonably well preserved. Other material of good quality scarce. Branches 0·32 to 0·4 mm wide. Apertural surface smooth or finely striate. Carina straight, rather sharp and prominent. Strong nodes, few of them preserved on the type, about 0·6 to 1·0 mm apart. Apertures 0·12 to 0·15 mm in diameter, usually 0·4 mm apart. Three apertures per row per fenestrule, one often placed at base of dissepiment. Rims of apertures not developed into peristomes. Fenestrules rectangular, 0·9 to 1·4 mm long, usually 1·0 mm. Dissepiments 0·12 to 0·16 mm wide in the centre, striated horizontally on the obverse. Zoecia almost hemi-hexagonal, about 0·16 mm wide.

MIRCOMETRIC FORMULA:

B/10	D/10	Z/5	N/5	BW	ZD	Z/F
14–15	9–10	15	5–8	0·4	0·1	3–4

Remarks.—The species is a generalized form of *Fenestella* with few distinguishing characteristics. As in *micropora,* the channel between the central keel and lateral keel mentioned by Campbell (1961, p. 459), is probably the result of crushing. The zoecial fronts are of thin carbonate. When they collapse as a result of compression normal to the obverse surface, they are depressed further than the more thickened top lateral margin of the branch, which is left projecting as an apparent lateral carina. I have noticed in various species that the tendency for apertures to lie in a channel increases with the fineness of grain of the sediment in which the specimens are preserved.

This species may be confused with *F. micropora.* Both are regular, fairly fine species with straight, prominent carinas, but *micropora* is consistently the finer of the two and has comparatively stronger and more closely and evenly spaced nodes, with one fewer aperture per row per fenestrule.

Fenestella osbornei has similar mesh dimensions, the same number of apertures per row per fenestrule, and both species have nodiferous carinas. The only consistent differences seem to be that *osbornei* has fewer apertures in the space of 5 mm and more evenly spaced, more numerous nodes. However, there are many specimens, especially those whose nodes are not well preserved, which cannot be confidently placed in one or other of the species.

For this reason, and because of the comparative scarcity of specimens, I am uncertain of the stratigraphic ranges of this species and *F. osbornei.* However, both Campbell (1961) and Maxwell (1964) thought that *loganensis* was more restricted in range in the Upper Carboniferous than *osbornei.*

Fenestella osbornei (Crockford, 1949)

Pl. 1, figs 7–8

1949 *Fenestrellina osbornei* Crockford, p. 424, fig. 5.

1961 *Fenestella osbornei* (Crockford). Campbell, p. 460, pl. 59, fig. 3.

1964 *Fenestella osbornei* (Crockford). Maxwell, p. 58, pl. 12, figs 9–10.

1964 *Fenestella osbornei* (Crockford). In Hill, D., and Woods, J. T., eds, pl. C III, figs 7–8.

Material.—Holotype US7430, from the "Upper Kuttung Series", Stroud, New South Wales. Specimens mentioned by Crockford (1949): UQF24949; UQF-34947. The latter is a specimen of *Polypora neerkolensis.* Crockford mentioned a specimen of *osbornei* on the piece of rock 8913, but the species cannot be found on the sample.

Description.—Holotype very poorly preserved mould of obverse surface about 28 mm wide and 9 mm high, probably from mature stage of zoarium. Branches of species about 0·25 mm wide. Obverse of branch smooth, with narrow, rather sharp carina with sharp, high nodes 0·4 to 0·6 mm apart, fairly regularly spaced. Apertures 3 per row per fenestrule, occasionally 4; not stabilized with respect to dissepiments, and not encroaching on fenestrules. Apertures about 0·13 mm in diameter, about 0·28 to 0·36 mm apart. Fenestrules oval to rectangular with rounded ends, regular in size, usually less than twice as wide as branches, typically 1·0 mm long and 0·4 mm wide. Dissepiments fairly narrow, usually about 0·05 to 0·1 mm wide in the centre. Zoecial base shape distorted hemi-hexagonal. Bases about 0·32 mm long and 0·18 mm wide.

MICROMETRIC FORMULA:

B/10	D/10	Z/5	N/5	B/W	ZD	Z/F
14–18	10–12	13–16	about 12	0·25	0·13	3–4

Remarks.—This species is probably the least well known of the described Upper Carboniferous fenestellids. The search for good material has not been as successful as it has for most of the other species. As mentioned above, it is easily confused with *F. loganensis.* More material will have to be studied before it is possible to determine the ranges of the species. At least one of them ranges from the base of the *Levipustula* Zone (Campbell and McKellar, 1969) in the Neerkol Formation to the top of the formation. Campbell (1961) and Maxwell (1964), thought *osbornei* was the longer ranging form.

Fenestella malchi (Crockford, 1949)

Pl. 2, figs 1–3

1949 *Fenestrellina malchi* Crockford, p. 422, fig. 4.
1961 *Fenestella malchi* (Crockford). Campbell, p. 460.
1964 *Fenestella malchi* (Crockford). Maxwell, p. 38, pl. 12, fig. 13.

Material.—Holotype UQF24952, from Malchi Creek, Neerkol Formation, central Queensland. Specimen mentioned by Crockford (1949), UQF-24953; Topotypes, GSQF10903–4.

Description.—Holotype well preserved, with some internal zoecial moulds. About 45 mm long and 15 mm wide, probably from the early mature stage of a zoarium. Branches of species 0·3 to 0·4 mm wide. Obverse finely striated between apertures. Dissepiments also striated along their length. Carina high, massive with rounded crest. At bifurcation, carina of parent branch continues along one new branch and a new carina arises for the other new branch. New carina small where it attaches to main carina, and there is a node at the junction. Very prominent nodes in single series on carina, flattened laterally, usually about 0·9 mm apart; their bases as large as apertures. Apertures circular, about 0·15 mm in diameter, with very low and weak peristomes. Apertures usually 0·5 to 0·6 mm apart, and generally four per row per fenestrule; not stabilized with respect to dissepiments. Fenestrules 0·8 to 1·5 mm long and usually 0·5 mm wide, fairly regular in size. Zoecial bases elongate hemi-hexagonal, 0·5 to 0·6 mm long, about 0·16 mm wide; vestibules not much constricted. Hemisepta not seen. Circular depressions in surfaces of branches; usually lying partly on carina and partly on apertural surface, particularly near base of type specimen. Depressions almost hemispherical, bordered by slight rim. Positions of depressions with respect to apertures not known. Rims about 0·82 to 0·88 mm in diameter.

MICROMETRIC FORMULA:

B/10	D/10	Z/5	N/5	BW	ZD	Z/F
13–15	7	12	5–6	0·35	0·15	4

Remarks.—This species is one of the more coarsely meshed Fenestellas of the Upper Carboniferous, with rather gross features as follows: a thick, high carina; large, widely spaced nodes; comparatively small, but widely spaced apertures, only 4, rarely 5, per row per fenestrule. The hemispherical depressions on the branch obverse surfaces are very similar to those on the surface of *"Polypora" pustulosa* (q.v.), which I interpret as ovicellular structures.

Fenestella cerva Campbell is very similar to *F. malchi* in all respects except that it has longer fenestrules. It is probably conspecific. At first glance, *F. crockfordae* Campbell is very similar to *F. malchi,* but cannot be reckoned conspecific with it because of its much coarser mesh, wider node spacing and larger apertures.

Maxwell (1964) declared *F. malchi* to be diagnostic of the "Middle Carboniferous", but said some individuals occurred in the Upper Carboniferous. Campbell (1961) found it in the Isaacs Formation of Stephanian age (Campbell and McKellar, 1969, p. 90). I have found only a few specimens in the Neerkol Formation, all in the *Levipustula* Zone. Although it seems to be rather rare at Neerkol, it is widely distributed geographically. It has been recognized at Yarrol (Maxwell, 1964) and Mount Barney (Crockford, 1949), and in New South Wales by Campbell (1961) and by Crockford (1949). I am not certain of its vertical range, but I suspect it is fairly short.

Subgenus *Bajoola* Fleming, 1966

Type species.—*Bajoola capellae* Fleming, 1966, Givetian, central Queensland.

Fenestella (*Bajoola*) *cincta* (Crockford, 1949)

Pl. 2, figs 4–6

1949 *Fenestrellina cincta* Crockford, p. 425.
1961 *Fenestella* cf. *cincta* (Crockford). Campbell, p. 460.
1964 *Fenestella cincta* (Crockford). Maxwell, p. 38, pl. 13, fig. 1.

Material.—Holotype, given by Crockford as UQF8919, cannot be located. An endeavour to locate it in the Universities of Queensland and Sydney was unsuccessful. The neotype here selected is GSQF-10898 from Malchi Creek, GSQL996, Ridgelands 1 mile sheet area 265791. Topotypes: GSQF10890, 10891a, b, GSQF10897a, b.

Description.—Neotype a fragment about 30 mm long and 12 mm wide, a well preserved mould of the obverse with two apertures surrounded by the semi-circular rims characteristic of the species, but not present on all specimens. Zoaria with coarse, rather irregular mesh. Branches sinuous, about 0·6 to 0·9 mm wide. Fenestrules generally long, up to 4 mm or more, sometimes only 1 mm, and occasional very short ones present. Dissepiments 0·2 to 0·3 mm wide, strongly striated along their length. Obverse of branches ornamented by fine longitudinal ridges between apertures. Apertures 0·4 to 0·7 mm apart, usually 0·5 mm. Thin, but prominent peristomes around the slightly pustulose apertures. Perforated plates across apertures mentioned by Crockford (1949, p. 425) not observed. Some apertures surrounded by the carina as well as a semi-circular ridge extending to near branch margin (see pl. 2, figs 4–5). Apertures in these positions often smaller, and sometimes no aperture present in depression within rim. Ends of rims against carina not as high as carina, but sharper. These structures are nearly always present, but are not as common as is indicated by Crockford's text-fig. 8. Carina very high and stout, rounded on top, marked off from branch surface by sharp change in slope. Carina sometimes heavily thickened. Carina does not bifurcate with branch; it is continuous along one of the new branches, but other branch has new carina arising opposite point of bifurcation from two or three short, fine ridges not

connected to the main carina. Either left or right new branch may bear the new carina. The continuous part of the carina in some cases is itself divided into two or more ridges (see pl. 2, fig. 6). Aperture lodged in angle of bifurcation. Zooecia elongate on the basal plate, distorted hemi-hexagonal, about 0·6 to 0·7 mm long and 0·25 to 0·3 mm wide. Vestibules not much constricted, no hemisepta.

Remarks.—This species is included in *Bajoola* because of its strong, nodeless carina, but it differs in many respects from the fine, regular type of the subgenus, *B. capellae* from the Givetian of central Queensland (Fleming, 1966). Miller (1961, p. 494) included forms with widely different mesh dimensions in his *Levifenestella* on the grounds of their not having carinae, and a similar course is taken here with regard to the species included in *Bajoola. Bajoola cincta* is the most easily recognized of the fenestellids in the Upper Carboniferous. It has many distinctive features: coarse irregular mesh; strong, nodeless carina; large apertures of which there are many per row per fenestrule; and semi-circular ridges on the obverse. The shape of the carina in *cincta* is rather unusual and quite characteristic. *Fenestella malchi* is similar in the way the carina behaves at branch bifurcation, but in *malchi* there is a connexion between the old and new carinas. The function of the depressed apertures surrounded by rims is not known. Specimens at my disposal are not preserved as complete skeletons, but only as moulds, and, unlike some specimens of *"Polypora" pustulosa,* none are preserved with internal infillings near these unusual structures. The fact that apertural modification sometimes accompanies the presence of the rims suggests that an ovicellular function is involved.

I would place the specimens mentioned by Campbell (1961, p. 460) in *cincta* s. str. The points of distinction noted by Campbell between his and the type material are attributable to the mode of preservation of the New South Wales specimens and to inadequacy of Crockford's original description.

This species is believed to be long ranging. It occurs in the Neerkol Formation from low in the *Levipustula* Zone to the top of the formation. Campbell (1961) found *B. cincta* only in the Booral Formation. Maxwell (1964) found it, according to his text, only in the Rands Formation, but his Table 2 shows it as occurring in the "Middle Carboniferous" Poperima Formation. These occurrences are probably consistent with only part of its range in the Neerkol Formation.

Genus *Polypora* McCoy, 1844

Type species.—Polypora dendroides McCoy, 1844, Tournaisian, Ireland.

Remarks.—Two species, *"Polypora" pustulosa* and *"P". palenensis,* described below, are included provisionally in *Polypora,* but differ from the type species, described by Miller (1963), in having nodeless obverse surfaces. The material available is sufficiently well preserved and plentiful to leave no reasonable doubt of the absence of nodes. In this respect, the species are similar to *P. ? verrucosa* McCoy (Miller, 1963, p. 169) and may be grouped with some other Australian species, among which are *P. isaacensis* Campbell, 1961, *P. sulcifera* Crockford, 1947, *P. wadei* Crockford, 1957; and probably *P. scalpta* Campbell, 1961. It appears, on examination of the literature, that nodeless species like *Polypora* are rather rare compared with species bearing nodes in various situations of the obverse. It is deemed inadvisable to erect a new generic category based on one of the nodeless species as type, because of the lack of material suitable for study in thin section.

Polypora neerkolensis Crockford, 1949
Pl. 3, figs 4–7

1949 *Polypora neerkolensis* Crockford, p. 426, fig. 10.
1962 *Polypora neerkolensis* Crockford. Campbell, p. 46, pl. 13, figs 1a–d.
1964 *Polypora neerkolensis* Crockford. Maxwell, pl. 13, figs 8–9.

Material.—Holotype UQF25005, from Por. 127v or 202, Par. Palen. Other UQ specimen mentioned by Crockford; UQF24989, from Por. 2v, Par. Stanwell. UQF24999 is labelled as Crockford's specimen of *neerkolensis,* but is a specimen of *P. pustulosa.* Topotypes: GSQF10929–30, GSQF10934, from 853927 Mount Lindesay 1-mile sheet area (GSQL-1010). Other material: GSQF10892–10894, Malchi Creek, 265791 Ridgelands 1-mile sheet area (GSQL996).

Description.—Holotype probably from mature stage of zoarium, partly silicified, obverse surface not preserved, but erosion has not proceeded to zoecial fronts. Portion of surface figured by Crockford is the only reasonably complete part of zoarium. UQF-24989 is a badly weathered obverse mould. Mesh regular and fairly fine, branches often wider than fenestrules, which are about 0·9 to 1·8 mm long, usually about 0·4 mm wide. Branches about 0·5 to 0·75 mm wide where there are three rows of apertures, 1 mm immediately below bifurcation, 0·4 mm above. Dissepiments 0·35 to 0·6 mm wide, usually about 0·4 mm. Apertures very large, 0·18 to 0·2 mm in diameter, with thin, low peristomes, about 0·35 to 0·5 mm apart. Surface between apertures rather depressed, and ornamented by discontinuous curved ridges and grooves. Apertures in diagonal rows when three or more vertical rows are present. Many specimens have strongly depressed, smooth branch surfaces, believed to be due to crushing and abrasion. Very occasional small surface spines present, some lying next to apertures where they seem to replace a section of the peristome. Zoecia sac-shaped, usually about 0·2 mm wide, with oval bases; vestibules constricted laterally. Very little overlap between zoecia in any row, practically no overlap between rows. Apparently no hemisepta.

MICROMETRIC FORMULA:

B/10	D/10	Z/5	N/5	BW	ZD	Z/F
9–10	7	12	rare	0·4–1	0·2	4–5

Remarks.—*Polypora neerkolensis* is difficult to identify from the original description and figure, and the species has been confused with *"P". pustulosa* Crockford. For example, Maxwell (1964, p. 39) identified some specimens of *pustulosa* as *neerkolensis. Polypora neerkolensis* is characterized by its regularity of mesh, wide branches, and particularly by its large, non-septate apertures which sometimes have spinose nodes against the edges. *"Polypora" pustulosa,* which is described below, is always smooth between its smallish septate apertures, lacks nodes, and often possesses hemispherical depressions about twice the size of the apertures in its obverse surface.

The nodes on *neerkolensis* are not arranged on the branch midline as in *P. dendroides,* nor are they of the same type, broad-based, grooved, with perforate apices. There are tubules in the tissue of *neerkolensis* between apertures, but they do not seem to be arranged in rings around them. Nodes have not been seen in the very small amount of material I have available for sectioning. The species is tentatively placed in *Polypora* s. str., but many questions about its morphological similarity to the type species as yet remain unanswered. It is interesting to note in Campbell's remarks (1962, p. 47) that the nodes on his material were rather large and placed towards the midlines of the branches, but lay against the apertures. The meaning of this variation is not known.

In the Neerkol Formation, *P. neerkolensis* is restricted in range to the early part of the *Levipustula* Zone. In New South Wales near Kempsey, in the Kullatine Formation, the species occurs with a fauna which is closely comparable with the lower *Levipustula* Zone in the Neerkol Formation. Maxwell (1964, p. 39) declared it to have been found through eastern Queensland in beds of "Middle" and Upper Carboniferous age. Most of the specimens cited by Maxwell as belonging to *neerkolensis* are actually *pustulosa* and only some of Maxwell's from the Poperima Formation are *neerkolensis.* It appears, therefore, that this species is restricted to horizons equivalent to the lower part of the range of *Levipustula levis.*

"Polypora" pustulosa Crockford, 1949

Pl. 3, fig. 8; pl. 4, figs 1–6; text-figs 1–2

1892 *Fenestella internata* Lonsdale. Etheridge fil., p. 218, pl. 9, figs 6–7.
1949 *Polypora pustulosa* Crockford, p. 428, fig. 11.
1949 *Polypora tenuirama* Crockford, p. 426, fig. 9.
1961 *Polypora septata* Campbell, p. 462, pl. 58, figs 1-2.
1964 *Polypora neerkolensis* Crockford. Maxwell, p. 39, pl. 13, figs 8–9.
non 1964 *Polypora pustulosa.* Maxwell, p. 39, pl. 14, fig. 13.

Material.—Holotype, UQF24980, from Por. 2v, Par. Stanwell. The type of *tenuirama* is UQF24955, from Malchi Creek, Stanwell. UQF24954 is a second specimen identified by Crockford as *P. tenuirama.* Topotype GSQF10910. Other specimens GSQF11920, 10936, Neerkol Creek GSQF10905, 10988, 10989, 10889, Malchi Creek.

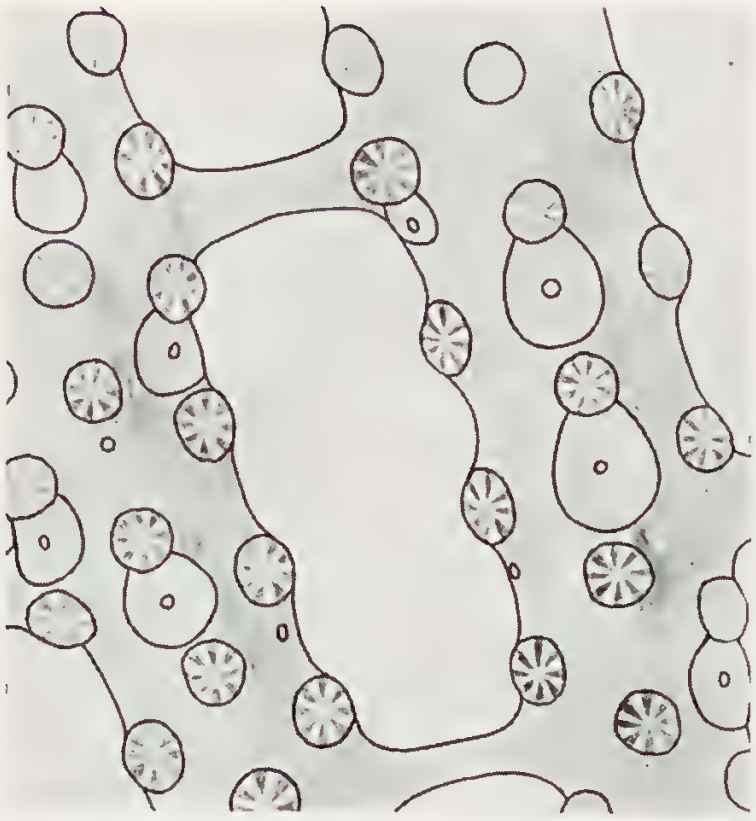
Description.—Holotype a badly weathered mould of obverse surface, but sufficiently preserved to be identified. Zoaria with regular and usually fine mesh, fenestrules oval to rectangular, usually about 1·5 to 2 mm long. Dissepiments rather thin, sometimes with apertures encroaching on them. Branches about 0·3 mm thick where there are 2 rows of apertures, increasing to about 1 mm before bifurcation where there are 4 rows. Usually 3 rows of apertures on most of branch. Obverse of branches and dissepiments finely pitted, branches with fine striations between apertures. Branch surfaces steeply rounded. Hemispherical pits common on the branch surfaces of most specimens, situated so that their distal margins lie against the proximal rims of apertures. Pits sometimes have slight encircling rims. They are 0·25 to 0·35 mm in diameter, some have a tiny aperture preserved in the bottom. A tiny opening in some places just behind apertures, with tube leading toward vestibule of adjacent zoecium. Similar tubules are doubtfully present opening into the base of hemispherical depressions. Apertures set on tops of pustulose elevations, and encroaching on fenestrules, only seldom on dissepiments. Usually 4, sometimes 5 per row per fenestrule; 4 rows before and 2 rows after bifurcation. Apertures rather small, about 0·45 to 0·5 mm apart, regularly 0·14 mm in diameter. 8 strong apertural septa extend only a short way down into aperture. Lowest inside tips of septa joined to circular plate with central perforation about 0·04 mm in diameter; plate seldom preserved. Zoecia sac-shaped, no overlap between rows, pointed proximally, base shape elongate oval. Strong constriction in vestibule. Inferior hemiseptum about 0·2 mm below distal edge of aperture. Rather strong superior hemiseptum present. Tubules leading independently of apertures to surface are thought to be connected to zoecium just above superior hemiseptum.

MICROMETRIC FORMULA:

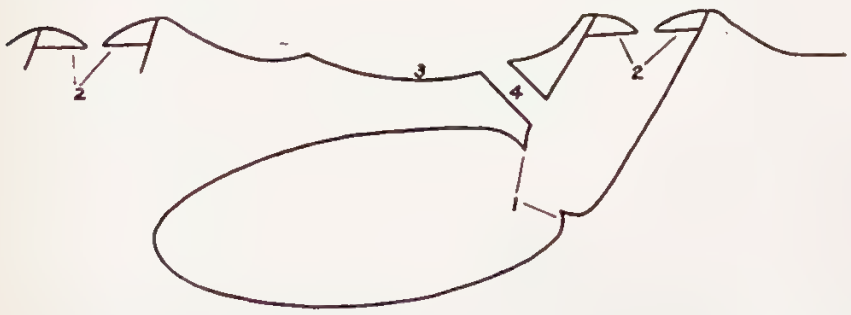
B/10	D/10	Z/5	N/5	BW	ZD	Z/F
9–11	8–9	0	0	0·14–0·8	0·14	4–5

Remarks.—The holotypes of *pustulosa* and *tenuirama* are the only specimens showing the obverse surface, and known to have been identified by Crockford. The type of *tenuirama* is identical with specimens of *pustulosa* except for its coarser mesh dimensions and more widely spaced apertures. Some specimens of *pustulosa,* such as that shown in pl. 4, fig. 3, are coarser than the holotype, but the type of *tenuirama* is much the coarsest identifiable specimen with the surface features of *pustulosa.* However, it is not considered that mesh size alone is sufficient reason for excluding the specimen from the species *pustulosa.*

The apertural septa of *pustulosa* were mentioned as spines by Crockford (1949) in her description of *tenuirama,* but she did not mention them in connexion with *pustulosa.* Campbell (1961) described the septate apertures of his species *P. septata,* here included in *pustulosa.*



TEXT-FIG. 1. Composite diagrammatic reconstruction of *"Polypora" pustulosa* showing eight septa in each aperture; hemispherical depressions; and small holes in surface, located in the depressions, and behind apertures where there are no depressions.



TEXT-FIG. 2. Diagrammatic vertical cross section through zoecial chamber and obverse surface of branch showing hemisepta (1), apertural septa (2), hemispherical depression (3), and tube leading from vestibule to depression (4).

Crockford described the hemispherical depressions in the surface of *pustulosa,* but not those present in her *tenuirama* material. She suggested, following a remark about similar structures by Ulrich (1890), that they were ovicells. Some specimens of *pustulosa* are devoid of the depressions, some have many, and others are intermediate. This type of occurrence would be expected of ovicells. The best preservation of internal structure in the specimens of *pustulosa* is shown by UQF24944, the holotype of *tenuirama.* From this specimen it is apparent that the hemispherical depressions in the surface are connected by a very fine tube to the underlying zoecial vestibule. In lying above the zoecium and being connected to it, this structure is comparable to that found in *Fenestella* sp. cf. *F. delicatula* Ulrich (Tavener-Smith, 1966, p. 194). It is possible that the depressions were covered during life by a fragile canopy of calcareous or other material which was always broken away before fossilization. The small holes sometimes appearing in the obverse surface behind apertures may be incompletely formed hemispherical structures. The species is devoid of nodes on the obverse surface.

"Polypora" pustulosa is widespread and common through the Upper Carboniferous and occurs in the Stephanian post-*Levipustula* fauna (Campbell and McKellar, 1969) at the top of the Neerkol Formation. Maxwell's (1964) identification of specimens of this species as *P. neerkolensis* led him to the belief that *pustulosa* was restricted in range.

"Polypora" palenensis (Crockford, 1949)

Pl. 3, figs 1–3

1949 *Polypora palenensis* Crockford, p. 427, fig. 18.

Material.—Holotype UQF25008, from Por. 127v or 202, Par. Palen, Mount Barney area. Other author's material UQF25009, same locality. Additional specimens; GSQF10909 from Malchi Creek, Neerkol Formation; GSQF10931a, b, Mount Barney area; UQF62187, topotype.

Description.—Holotype is a small zoarial fragment with no part of the obverse surface showing. Most of it is a reverse mould, but a tiny fragment has some of the tissue covering zoecial fronts preserved. This was the part figured by Crockford. Zoarium coarsely and rather irregularly fenestrate. Fenestrules large with rather square ends, usually 2·5 to 3·5 mm long and about 1·0 mm wide. Dissepiments narrow, expanding slightly near ends, about 0·25 mm wide in centre. Branches usually irregularly curved, about 0·7 mm wide immediately after bifurcation with three rows of apertures, and up to 2 mm wide before bifurcation where there are as many as 6 rows of apertures. Obverse branch surfaces rather flattened overall, but surface between apertures slightly raised and ornamented with minute, discontinuous curved ridges and grooves, not often preserved. Surface nodeless. Apertures do not encroach on dissepiment bases. Apertures 0·15 mm in diameter, about 0·5 mm apart in the rows. There are about 5 to 9 per row per fenestrule. Peristomes distinct. Small apertural septa have been seen in the species, but are very seldom preserved. Vestibules set at low angle to surface, zoecia sac-shaped, not overlapping between rows, oval in basal shape. A septal ring (perforated diaphragm) is present in the vestibule just inside the aperture, possibly formed by coalescence of hemisepta.

MICROMETRIC FORMULA:

B/10	D/10	Z/5	N/5	BW	ZD	Z/F
6–7	4	12	0	0·7–1·0	0·15	5–9

Remarks.—This species is not a well known form; its type is very badly preserved and it does not seem to be widely distributed. This may be due to failure of authors to recognize it from the original description. Crockford's description is amplified above,

with the aid of additional fairly well preserved material now available. Neither Campbell (1961, 1962) nor Maxwell (1964) recognized *"P". palenensis* in their faunas, but it occurs in the Neerkol Formation as well as at the type locality in the Mount Barney area. In the Neerkol Formation I have found the species only in a narrow band in the middle of the formation, near the top of the *Levipustula* Zone.

The characteristic appearance of the species is of wide, flexuous branches with flattened obverse surfaces and long fenestrules. It has only a small amount of calcareous tissue over its zooecial fronts, with rather wide apertures set closely together, and is nodeless. *P. scalpta* Campbell, 1961 is somewhat similar to *"P". palenensis* in appearance of the obverse surface, but the two are readily distinguishable on the basis of the much greater length of the fenestrules in *palenensis*.

CONCLUSIONS

1. *Fenestella cincta* (Crockford, 1949) is considered to be a representative of *Fenestella* (*Bajoola*) Fleming, 1966. *Polypora tenuirama* Crockford, 1949 is regarded as a synonym of *"P". pustulosa* Crockford, 1949. Because of their nodeless obverse surfaces, *"P". pustulosa* and *"P". palenensis* are provisionally included in *Polypora* McCoy, 1844. *P. neerkolensis*, with nodes on the obverse surface, is placed in *Polypora* McCoy.

2. As well as the species identified by Campbell (1961) as common to Queensland and New South Wales, *F. loganensis* Wass, *F. malchi, F. micropora, F. osbornei* and *Polypora neerkolensis*, there are a number of other species in common. The overall similarity is further extended by New South Wales species which are similar to Queensland species, but not necessarily conspecific. *Fenestella* (*Bajoola*) *cincta* occurs in New South Wales. *F. anodosa* Campbell occurs in the Yarrol Basin in Queensland (Maxwell, 1964). I regard *F. cerva* as probably indistinguishable from *F. malchi*, and *Polypora septata* Campbell as synonymous with *"P". pustulosa*. *Fenestella stellaris* Campbell is very much like *F. micropora* Crockford, and may be only *micropora* with ovicells. *Fenestella crockfordae* is similar to *F. malchi*. *Polypora isaacensis* differs from *"P". pustulosa* only in its fine mesh and spines on the reverse of some specimens.

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EXPLANATION OF PLATE 1

FIGS 1–4 *Fenestella micropora* (Crockford, 1949).

1. GSQF10911. Topotype. Latex cast of portion of obverse surface, nodes not well preserved (x 15).

2. Same. Latex cast of obverse, showing regular meshwork (x 4).

3. UQF24944b. Holotype. Latex cast of obverse, poorly preserved (x 10).

4. UQF24944a. Holotype. Latex cast of reverse, showing bases of pillars near branch bifurcations (x 6).

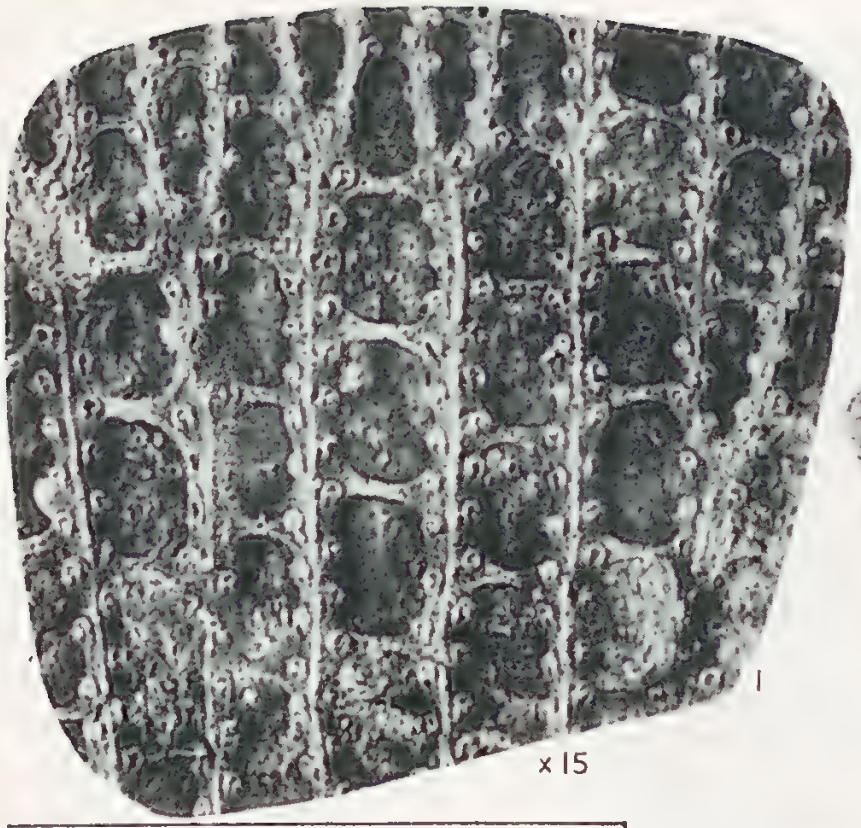
FIGS 5–6 *Fenestella loganensis* Wass, 1966.

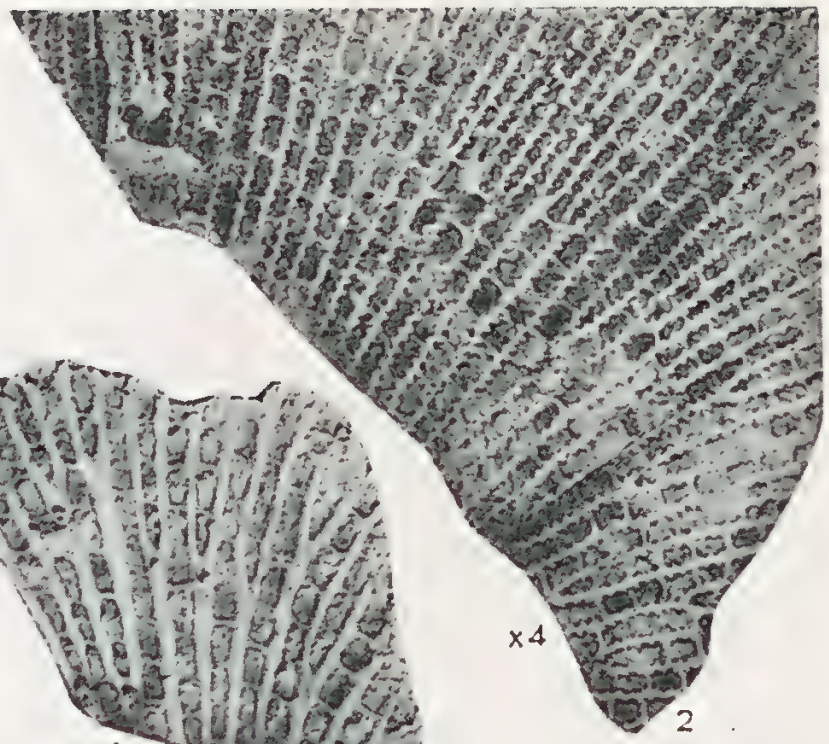
5. UQF24994. Holotype. Latex cast of obverse (x 4).

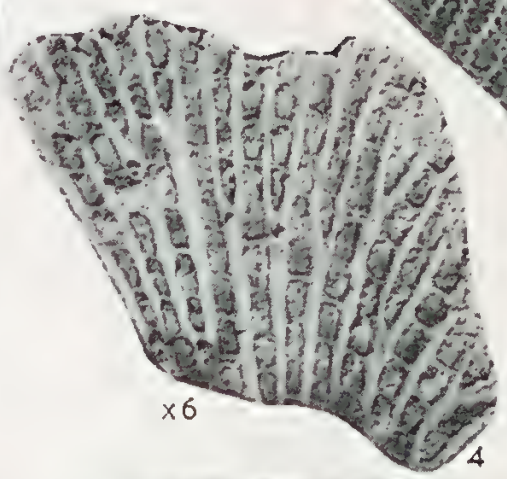
6. Same. Portion of surface enlarged, showing straight carina; apertural surface squashed, most nodes removed (x 12).

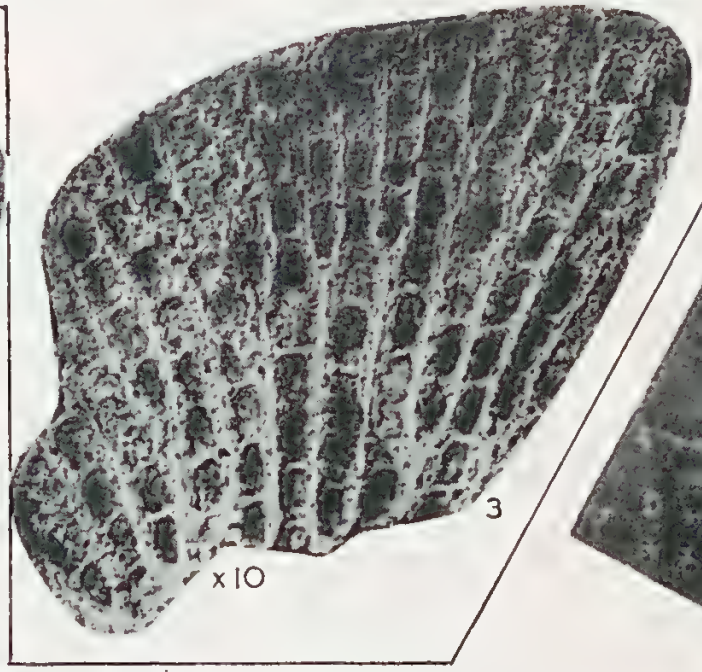
FIGS 7–8 *Fenestella osbornei* (Crockford, 1949).

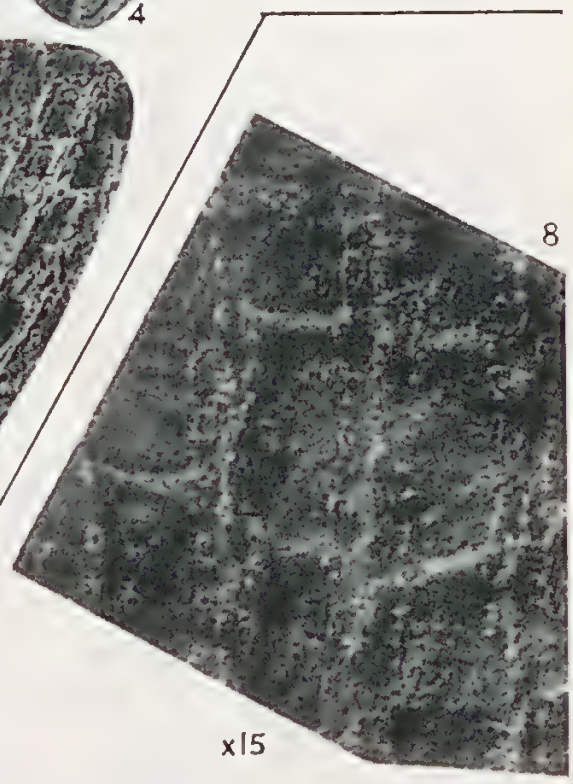
7, 8. USF7430. Holotype of *F. osbornei.* Latex cast of obverse. Branch surfaces crushed badly; features not properly distinguishable. Some nodes visible on straight, but badly preserved carina (7, x 10), (8, x 15).

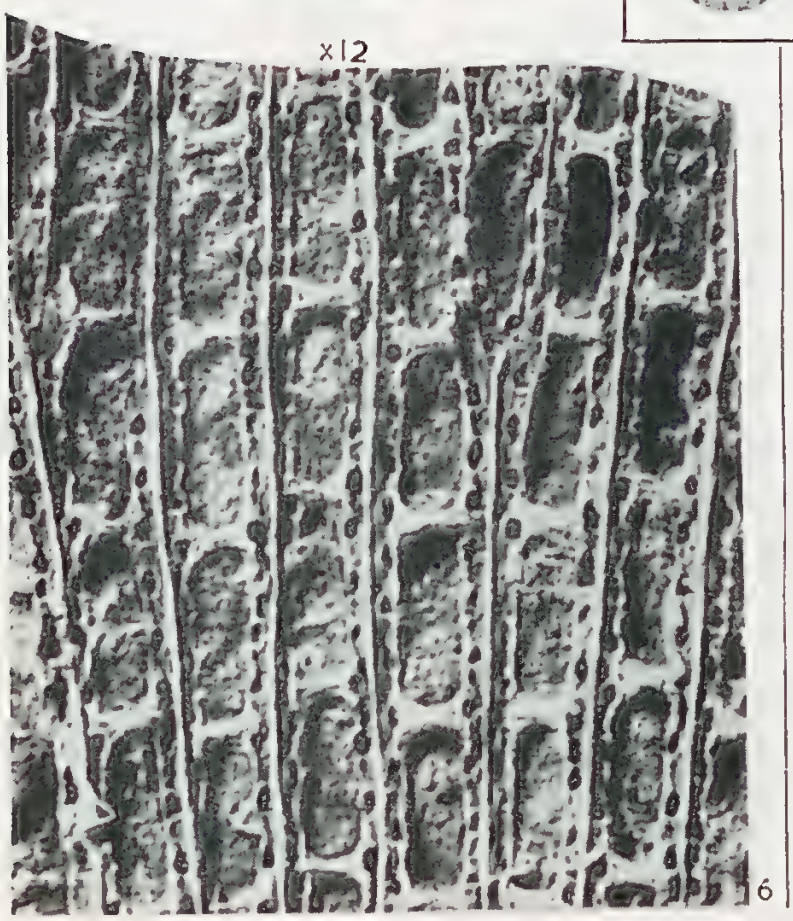












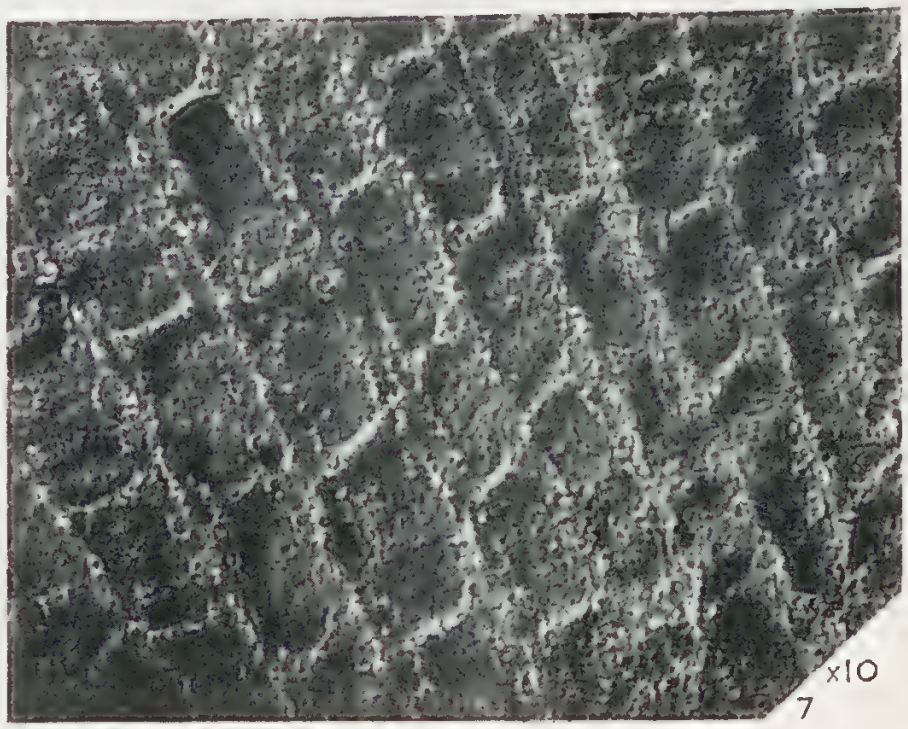


PLATE 1

EXPLANATION OF PLATE 2

FIGS 1–3 *Fenestella malchi* (Crockford, 1949).

1. UQF24952. Holotype. Latex cast of obverse showing rather coarse, but fairly regular meshwork (x 2).

2. Same. Latex cast of proximal portion lit from very low angle to show strong nodes evenly placed on high, thick carina (x 9).

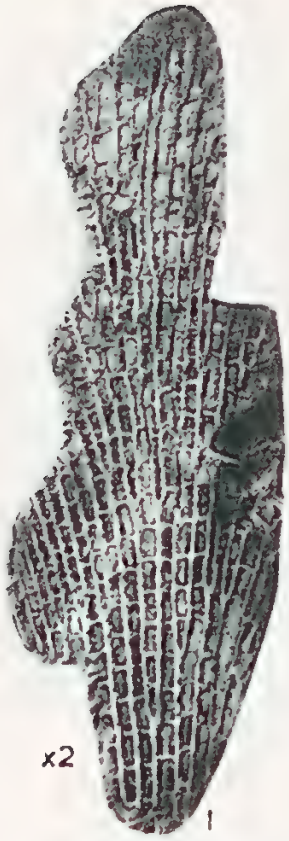
3. Same. Latex cast of distal portion lit from the "north" to show disposition of apertures (x 9).

FIGS 4–6 *Fenestella* (*Bajoola*) *cincta* (Crockford, 1949).

4. GSQF10898. Neotype. Latex cast of obverse. Sinuous branches with strong, nodeless carina and irregularly, usually widely spaced dissepiments (x 4).

5. Same. Portion of surface enlarged, showing two of the semicircular ridges surrounding modified apertures (x 10).

6. GSQF10897a. Topotype. Latex cast of portion of obverse, showing interapertural ornament and carinal characters (x 10).



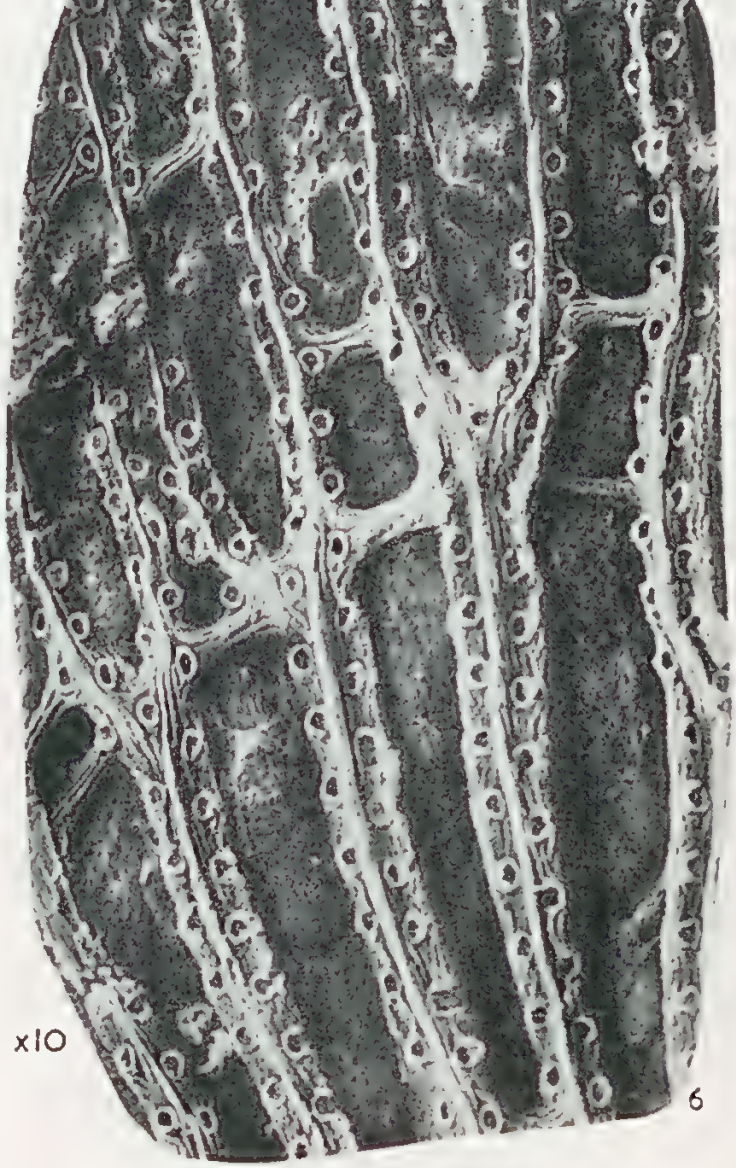


PLATE 2

EXPLANATION OF PLATE 3

FIGS 1–3 *"Polypora" palenensis* Crockford, 1949.

1. UQF25008. Holotype. Part of obverse surface, badly preserved and only small part of colony present (x 6).

2. UQF62187. Topotype. Latex cast of obverse surface with large, rather close apertures and flexuous branches (x 4).

3. Same. Portion enlarged (x 8).

FIGS 4–7 *Polypora neerkolensis* Crockford, 1949.

4. GSQF10894. Malchi Creek, Stanwell. Latex cast of obverse, somewhat squashed (x 10).

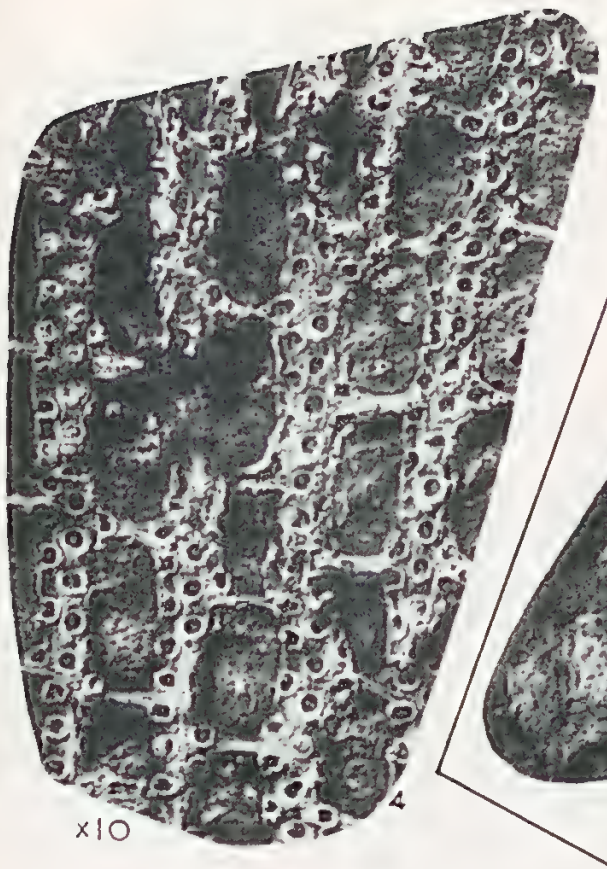
5. GSQF10893. Malchi Creek, Stanwell. Latex cast of obverse with fairly fine mesh and large, round apertures characteristic of the species. Ridges between apertures seldom preserved as well as on this specimen (x 10).

6. UQF32189. Neerkol Creek, Stanwell. Latex cast of obverse, rather worn and flattened (x 15).

7. UQF25005. Holotype. Small amount of calcareous material preserved, but surface badly weathered (x 11).

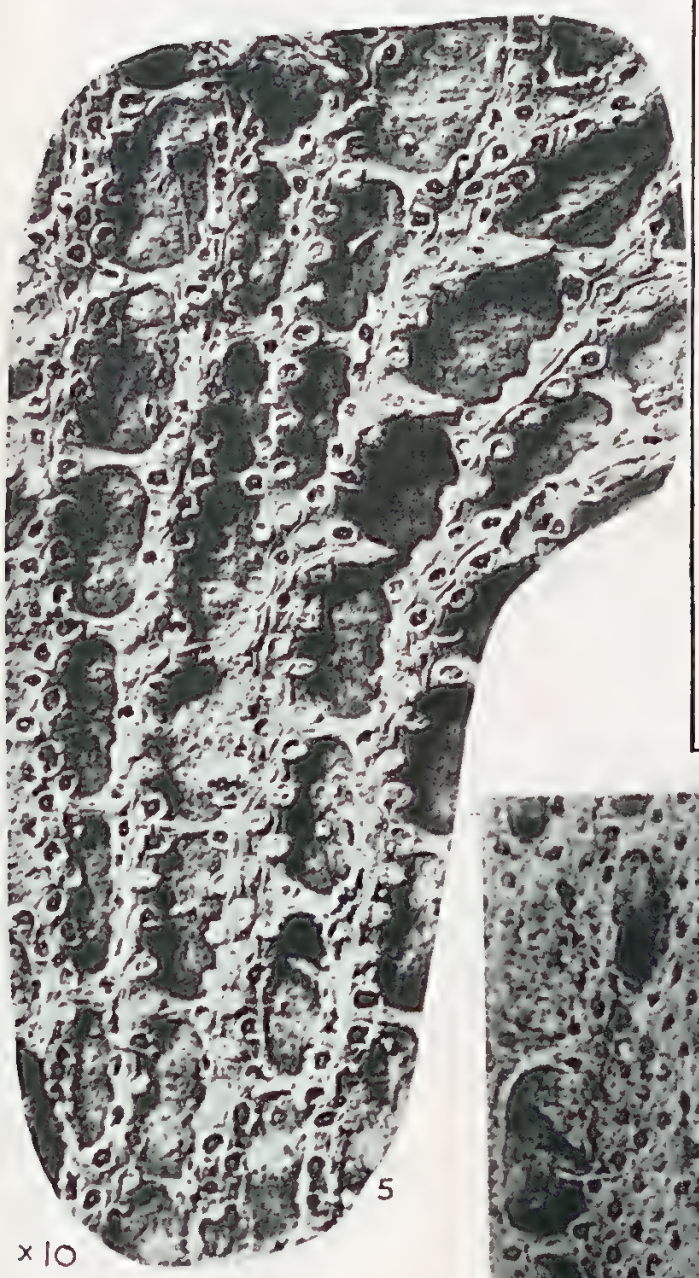
FIG. 8 *"Polypora" pustulosa* Crockford, 1949.

8. GSQF10889. Malchi Creek, Stanwell. Latex cast of obverse. To show difference in appearance between *pustulosa* and *P. neerkolensis* which are easily confused from the original descriptions (x 10).

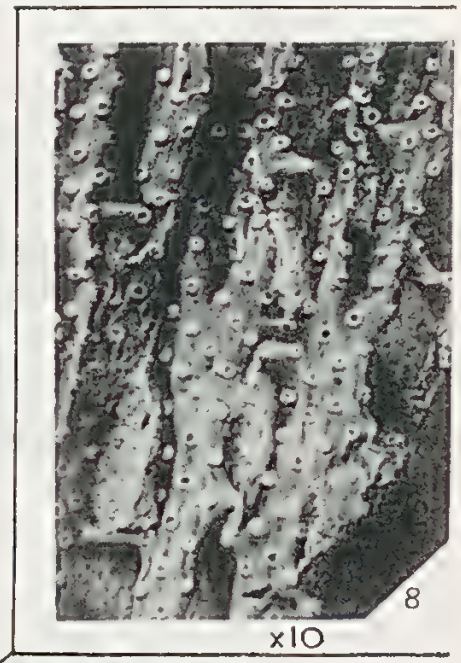

x10
4

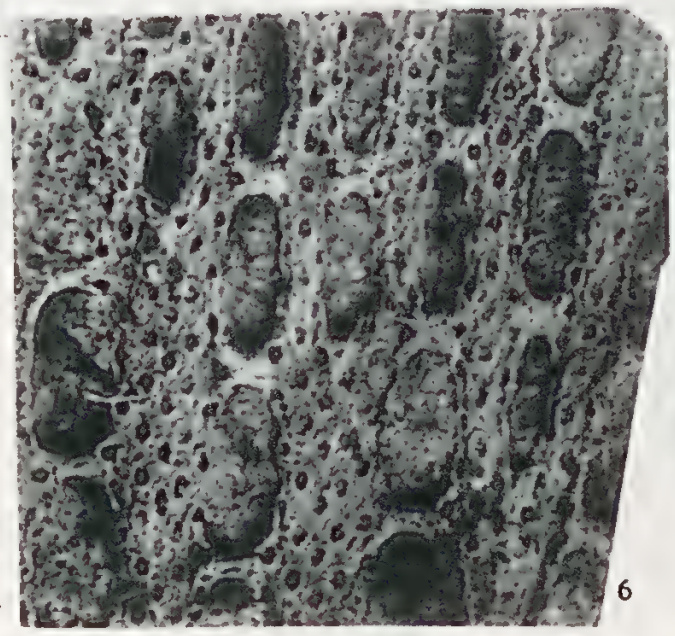
x6
1

x8
3


x10
5

x4
2


x10
8


x15
6

x11
7

PLATE 3

EXPLANATION OF PLATE 4

FIGS 1–6 *"Polypora" pustulosa* Crockford, 1949.

1. UQF24980. Holotype. Latex cast of obverse surface (x 2).

2. Same. Rather fine meshwork in this specimen. Surface poorly preserved (x 12).

3. GSQF10888. Malchi Creek, Stanwell. Latex cast of obverse. Well preserved specimen with rather open mesh (x 8).

4. GSQF10889. Malchi Creek, Stanwell. Pl. 3, fig. 8 is right hand bottom corner of this specimen slightly enlarged. Surface well preserved, branches and dissepiments broken (x 6).

5, 6. UQF24955. Type of *P. tenuirama* Crockford. Latex cast of obverse. Very well preserved. Apertures as in *P. septata* Campbell. Pits on surface behind apertures show clearly in fig. 6. (5, x 6), (6 x 18).

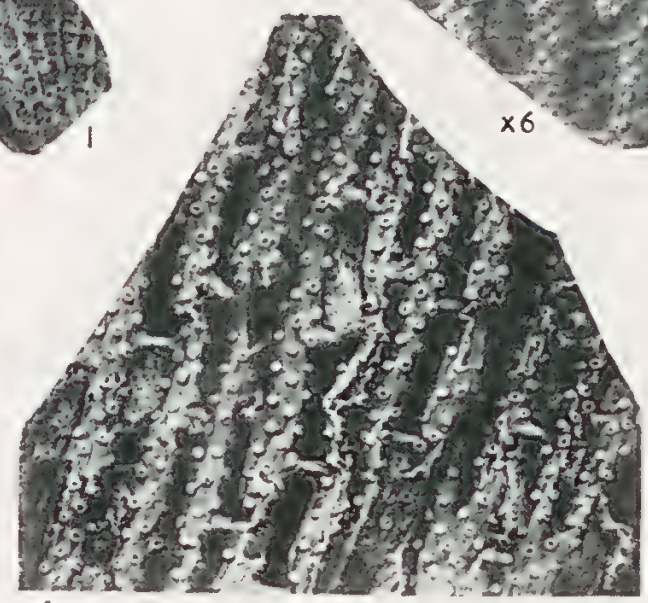


PLATE 4

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QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

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POLLEN AND SPORE ASSEMBLAGES FROM QUEENSLAND TERTIARY SEDIMENTS

by
H. HEKEL

BRISBANE
JULY, 1972

POLLEN AND SPORE ASSEMBLAGES FROM QUEENSLAND TERTIARY SEDIMENTS

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Geological Survey of Queensland

SUMMARY

Assemblages from 50 samples, from the Tertiary of eastern Queensland have been studied; five informal biostratigraphic units are proposed. Definition of these intervals is based on a combination of the oldest occurrence of species (possible evolution or migration) and statistical maxima of groups (local climatic influence). Marine sections from the offshore Capricorn Basin are used as standard profiles, with ages based on planktonic foraminifera, ranging from late Oligocene to Pliocene. There is evidence for an earlier age within the Tertiary of some onshore terrestrial deposits. Sediments in contact with dated basalts were used to provide an additional check on the ages of some units.

From the taxonomic aspect, about 100 species are recorded. Several new combinations and one new species are proposed. Some species differ from previously described forms, but are not formally designated as new species because of the lack of sufficient numbers of specimens. Generally the pollen assemblages are not as diversified as in southern areas of Australia and zonations established there cannot be applied in detail. Some species which have proved to be useful for 'pantropical zonation' have been found and minor differences in their distribution observed. Generally, angiosperm pollen species are predominant. In the Hillsborough Basin, however, a large scale alteration of pteridophyte and angiosperm predominance is reported. Evidence on the composition of the associated clay minerals suggests that this is related to climatic influences. A significant maximum of *Nothofagidites* is recorded from the Early Miocene.

INTRODUCTION

Sediments of Tertiary age are widely distributed in Queensland. Little is known in detail about their stratigraphic relationships. Plant macrofossils, vertebrates, insects, diatoms, and ostracods are known from freshwater sediments onshore (summarised in Hill and Denmead, 1960, pp. 341-423). Hardly any of these groups of fossils provides a more accurate age interpretation than Tertiary. On the other hand, marine sequences are known from oil exploration wells in the offshore area which can be accurately correlated with international biostratigraphic units (Palmieri, 1971).

The aim of the present study is to establish palynological units within the marine sections of known age and to try to correlate onshore terrestrial sediments with these units.

There are several previous papers on Queensland Tertiary palynology, although no comprehensive account is available. Cookson and Pike (1954) described several taxa from Mount Tamborine and Stradbroke Island. Harris (1965) described Tertiary microfloras from the Brisbane area and compared them with southern Australian assemblages. Additionally, there are unpublished company reports on Tertiary pollen and spores (Hodgson, *in* United Geophysical Corporation, 1965; Evans, *in* Ampol, 1965; Dempsey and Urban, 1965; Paten, *in* Carlsen and Wilson, 1968; Burgess, *in* Carlsen and Wilson, 1968), which contain data that are here discussed in more detail. Other unpublished information on pollen floras from Cape Hillsborough, is included in a BMR Record (Hodgson, *in* Clarke, Pain and Jensen, 1968).

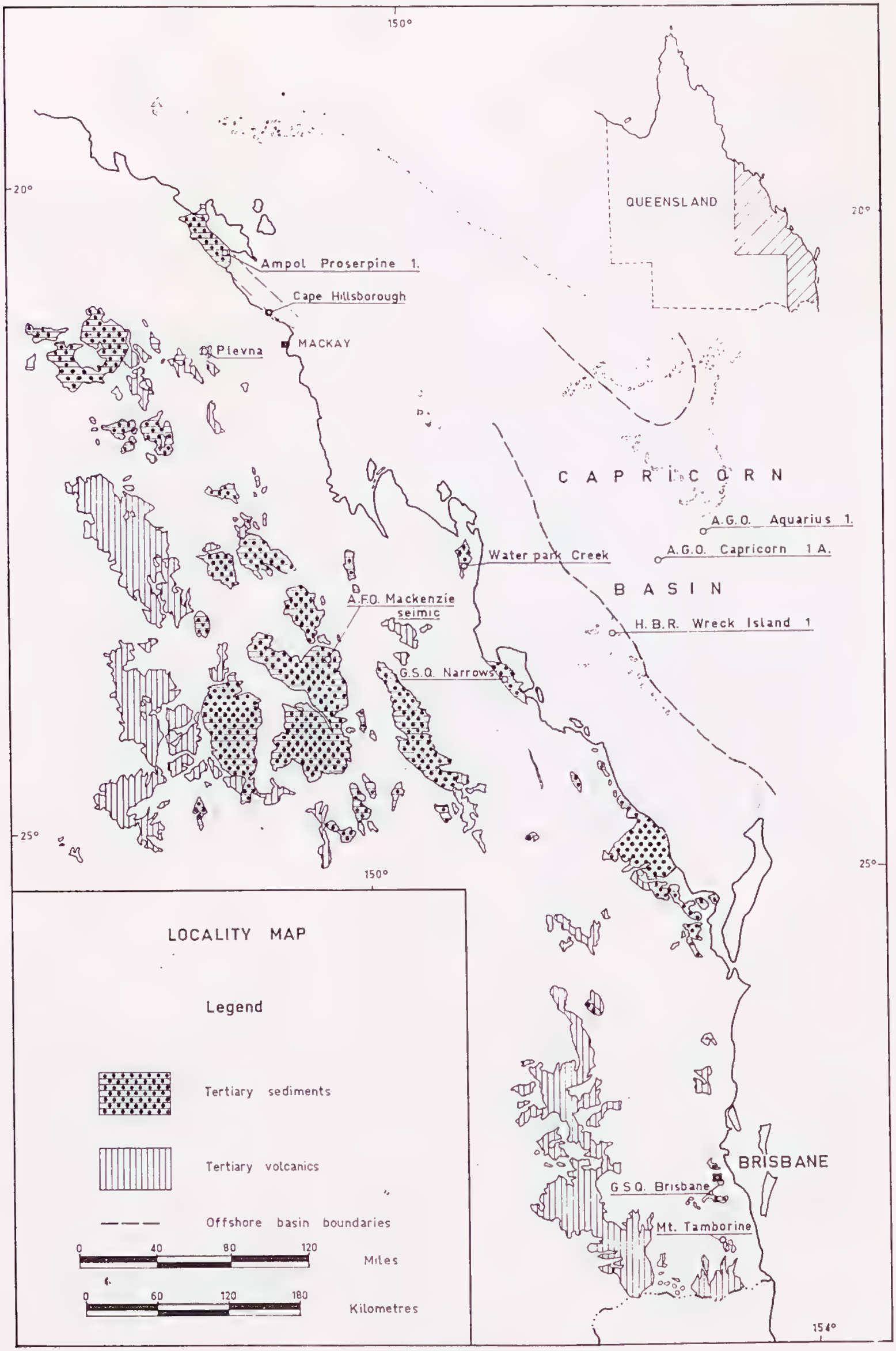
150°
20°
25°
QUEENSLAND
Ampol Proserpine 1.
Cape Hillsborough
MACKAY
Plevna
CAPRICORN
A.G.O. Aquarius 1.
A.G.O. Capricorn 1A.
Water park Creek
BASIN
A.F.O. Mackenzie seimic
H.B.R. Wreck Island 1
G.S.Q. Narrows
BRISBANE
G.S.Q. Brisbane
Mt. Tamborine
154°
LOCALITY MAP
Legend
Tertiary sediments
Tertiary volcanics
Offshore basin boundaries
0 40 80 120
Miles
0 60 120 180
Kilometres

Figure 1

SAMPLES

From 60 samples examined for pollen and spores, 50 proved to be fossiliferous. Most of the samples are cores from below the zone of weathering. Only a few localities permit direct access to unweathered surface samples. Outcrops close to the permanent water table are likely to be sufficiently unoxidised to contain fossil pollen. Beds of perennial rainforest creeks (Mount Tamborine, Waterpark Creek) and intertidal outcrops (Cape Hillsborough) show reasonably well preserved pollen.

The samples studied were obtained from cores from exploratory wells and Departmental stratigraphic drillholes, all stored at the Geological Survey of Queensland core library at Redbank.

The only marine sections, from which samples have been obtained, are those from offshore wells in the Capricorn Basin (Wilson, 1969)—A.G.O. Aquarius 1, A.G.O. Capricorn 1A, and H.B.R. Wreck Island 1. Samples of terrestrial sediments came from several localities in the onshore basins, in addition to the 'redbed section' in A.G.O. Aquarius 1. Sediments from the Hillsborough Basin were studied from Ampol Proserpine 1, M.O.P.S. 5, and outcrop material collected at Cape Hillsborough by V. Palmieri. Samples from the Duaringa Basin came from A.F.O. Mackenzie seismic shotholes H17 and A10.

Sediments underlying basalts at Hazlewood Creek near Plevna (Reid, 1942) were collected by C. Swarbrick. In the Waterpark Creek area, samples were collected from outcrops of a coal seam in Tomahawk Creek (Shepherd, 1951) and from Departmental drillholes Waterpark Creek N1 and N2. In the Narrows graben, samples from Departmental drillholes Narrows N1, N8, N9 and N12 (see Ball, 1946) have been studied. In the Brisbane area, samples from Departmental drillholes Brisbane NS4 in the Sunnybank Formation and Brisbane NS5 in the Darra Formation (see Houston, 1967) were examined. (All the above mentioned well names are abbreviated in the following text).

All samples were treated with the standard hydrofluoric acid-Schultze's solution-alkali technique. Most of the residues were subjected to specific gravity separation with zinc bromide solution. The residues were mounted in glycerine jelly. All microslides are stored in the palynological collection of the Geological Survey of Queensland.

The stage co-ordinates, given for each figured specimen in the taxonomic part of this paper refer to the mechanical stage No. 436094 of a Zeiss GFL standard microscope. The reference point listed for each slide refers to the lower right hand corner of the cover glass, when the slide is inserted with the label to the observer's left.

SYSTEMATIC DESCRIPTIONS

The following suprageneric arrangement is based on the classification of Potonié (1966).

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reisch *emend.* Dettmann, 1963

Subturma AZONOTRILETES Luber *emend.* Dettmann, 1963

Infraturma LAEVIGATI Bennie & Kidston *emend.* Potonié, 1965

Genus BIRETISPORITES Delcourt & Sprumont *emend.* Delcourt, Dettmann & Hughes, 1963

Type species:— *Biretisporites potoniaei* Delcourt & Sprumont, 1955.

Biretisporites spp.

Remarks:— Smooth specimens with elevated lips of various heights in the size range of 25-35μ have been found in pteridophyte-rich samples in the Proserpine 1 section. Bigger specimens (about 40μ) have been observed in the lignitic sections of the offshore wells. In particular the bigger specimens show extreme variation in the height of the lips, and such specimens may represent stages in maturity or preservation of *Cyathidites*.

Distribution:— Restricted to pteridophyte-rich samples throughout the sequence studied.

Genus CYATHIDITES Couper, 1953

Type species:— *Cyathidites australis* Couper, 1953.

Cyathidites minor Couper, 1953

Plate 2, Figure 4

Figured specimen:— Slide OD 3822, stage co-ordinates 3.6, 102.4, reference point 13.8, 85.8; diameter 34μ.

Locality:— Aquarius 1, Core 2, 1506 ft.

Remarks:— The small species *C. minor* (25-45μ) is quite common in samples with a predominance of pteridophytes, while only few specimens of *C. australis* have been observed.

Distribution:— Widely distributed in Mesozoic and Tertiary sediments. Common throughout the sections studied.

Genus DICTYOPHYLLIDITES Couper, 1958

Type species:— *Dictyophyllidites harrisii* Couper, 1958.

Dictyophyllidites sp. aff. *D. harrisii* Couper, 1958

Plate 2, Figure 8

Figured specimen:— Slide OD 3846, stage co-ordinates 28.3, 93.5, reference point 10.7, 86.5; diameter 40μ

Locality:— Capricorn 1A, S.W.C. 3117 ft.

Remarks:— The figured specimen is representative of a species of *Dictyophyllidites* which resembles *D. harrisii*, but has more pronounced interradial thickenings.

Distribution:— Widely recorded throughout the Mesozoic (see de Jersey, 1971). Relatively rare in the Queensland Tertiary.

Dictyophyllidites aff. *D. mortoni* (de Jersey) Playford & Dettmann, 1965

Plate 2, Figures 6 and 7

Figured specimens:— Fig. 6—Slide OD 3635, stage co-ordinates 10.7, 88.5; diameter 24μ. Fig. 7—Same slide, stage co-ordinates 3.5, 95.0, reference point 14.4, 78.1; diameter 24μ.

Locality:— Proserpine 1, Core 5, 1982 ft.

Remarks:— A small spore in the size range of *D. mortoni*. These Proserpine specimens show irregular membraneous lips, often partly broken away.

Distribution:— Widely recorded from Mesozoic and Tertiary sediments. For Queensland Mesozoic records see de Jersey (1971). Queensland Tertiary: unit 1, common in samples with predominance of pteridophytes in Proserpine 1.

Infraturma APICULATI Bennie & Kidston, *emend.* Potonié, 1965

Subinfraturma VERRUCATI Dybová & Jachowicz, 1957

Genus OSMUNDACIDITES Couper, 1953

Type Species:— *Osmundacidites wellmanii* Couper, 1953.

Osmundacidites sp.

Plate 2, Figure 10

Figured specimen:— Slide S 2765, stage co-ordinates 1.5, 88.8, reference point 13.0, 85.6; diameter 48μ.

Locality:— Waterpark Creek N2, 195 ft.

Remarks:— The specimens recorded here are within the size range of, and similar to *O. wellmanii* Couper. The surface sculpture when well preserved seems to be more irregular and a reduction of the sculpture towards the tetrad scar (characteristic of that species) could not be observed.

Distribution:— Rare throughout the Queensland Tertiary.

Infraturma MURORNATI Potonié & Kremp, 1954

Genus LYCOPODIUMSPORITES Thiergart, 1938

Type species:— *Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938.

Lycopodiumsporites sp.

Plate 2, Figure 11

Figured specimen:— Slide S 2523, stage co-ordinates 3.9, 102.3, reference point 13.7, 86.4; diameter 29μ.

Locality:— Brisbane NS5, 270 ft.

Remarks:— At least three different specific types have been observed, but because of their relative rarity, no formal identifications have been made.

Distribution:— Sporadic throughout the sequence and presumed to be affected by ecologic factors.

Genus CICATRICOSISPORITES Potonié & Gelletich, 1933

Type species:— *Cicatricosisporites dorogensis* Potonié & Gelletich, 1933.

Cicatricosisporites sp.

Remarks:— Several specimens similar to *C. australiensis* (Cookson) Potonié, 1956 have been found in the Proserpine 1 sediments.

Distribution:— *C. australiensis* is widespread in the Lower and Upper Cretaceous of Australia (Dettmann, 1963). Specimens described as *C. dorogensis* by Muller (1968) are common in the Cretaceous and rare in the Paleocene-Eocene of Borneo. Queensland Tertiary: reworked (or persistent?) in Proserpine 1.

Genus CRASSORETITRILETES Germeraad, Hopping & Muller, 1968

Type species:— *Crassoretitriletes vanraadshooveni* Germeraad, Hopping & Muller, 1968.

Crassoretitriletes vanraadshooveni Germeraad, Hopping & Muller, 1968

Plate 2, Figures 9 and 12

Figured specimens:— Figure 9—Slide OD 3790, stage co-ordinates 6.6, 90.0, reference point 12.9, 87.0; diameter 55μ. Figure 12—Slide OD 3691, stage co-ordinates 9.8, 92.2, reference point 11.8, 88.4; diameter more than 55μ.

Localities:— Figure 9—Mackenzie seismic A10, 465-480 ft. Figure 12—Capricorn 1A, S.W.C. 2877 ft.

Remarks:— Rare, but very characteristic in size, proximal ornamenation and wall structure.

Distribution:— In Nigeria from latest Oligocene, in Borneo from the higher part of early Miocene onward, in the Caribbean area restricted to upper part of early Miocene (Germeraad, Hopping and Muller, 1968). Queensland Tertiary: units 3 and 4, from base of the early Miocene to late Miocene.

Turma ZONALES Bennie & Kidston *emend.* Potonié, 1965

Subturma AURITOTRILETES Potonié & Kremp, 1954

Infraturma AURICULATI Schopf *emend.* Dettmann, 1963

Genus ROUSEISPORITES Pocock *emend.* Dettmann, 1963

Type species:— *Rouseisporites reticulatus* Pocock, 1962

Rouseisporites sp.

Plate 2, Figure 13

Figured specimen:— Slide OD. 3714, stage co-ordinates 3.1, 99.5, reference point 12.4, 85.4; diameter 50μ without muri.

Locality:—Aquarius 1, Core 10, 5081 ft.

Description:— Trilete spore, with subcircular amb and indistinct laesurae. Exine 1.5-2μ thick. Membraneous outer layer (often partly removed when overoxidised), forming isometric, irregular reticulum with lumina of about 5-10μ on distal and proximal regions. Muri light and thin, when unoxidised up to 5μ high.

Remarks:— Assignment of this spore to *Rouseisporites* would be possible if it is assumed that it represents an azonate member of this genus. *Zlivisporis* Pacltova (1961) has a similar irregular reticulum, but this is restricted to the distal side.

Distribution:— Queensland Tertiary: units 1 to 3 in Aquarius 1 and Narrows N1.

Genus POLYPODIACEOISPORITES Potonié, 1956

Type species:— *Polypodiaceoisporites speciosus* (Potonié) Potonié, 1956.

Polypodiaceoisporites sp. aff. *P. retirugatus* Muller, 1968

Plate 2, Figures 2 and 3

Figured Specimens:— Figure 2—Slide OD 3657, stage co-ordinates 30.9, 101.8, reference point 10.8, 91.0; diameter 31μ.

Localities:— Figure 2—Proserpine 1, Core 1, 763 ft. Figure 3—Outcrops at Donna Bay, north coast of Cape Hillsborough peninsula.

Remarks:— These spores resemble *P. retirugatus* Muller, but have a size range of 25-44μ, and are outside the size range of *P. retirugatus* (44-61μ). *P. obscurus* Harris, 1965 shows smaller distal sculptural elements.

Distribution:— Queensland Tertiary: unit 1 to unit 5, particularly in Proserpine 1 and Narrows Beds.

Affinities:— Quite similar morphologically to spores from the fern genus *Pteris*, as noted by Muller (1968).

Genus GLEICHENIIDITES Ross *emend.* Skarby, 1964

Type species:— *Gleicheniidites senonicus* Ross, 1949.

Gleicheniidites circinidites (Cookson) Dettmann, 1963

Plate 2, Figure 1

Figured specimen:— Slide S 2529, stage co-ordinates 6.5, 104.9, reference point 13.2, 88.1; diameter 29μ.

Locality:— Brisbane NS 5, 138 ft.

Distribution:— In late Mesozoic and Tertiary (see Dettmann, 1963). Throughout the Queensland Tertiary sequence.

Affinities:— Close similarity of *Gleichenia cercinata* Swartz (Cookson, 1953).

Gleicheniidites sp. aff. *G. circinidites* (Cookson) Dettmann 1963

Plate 2, Figure 5

Figured specimen:— Slide OD 3635, stage co-ordinates 32.6, 98.0, reference point 14.4, 78.1; diameter 21μ.

Locality:— Proserpine 1, Core 5, 1982 ft.

Description:— Trilete spore, triangular amb, sides convex to concave, tetrad scar reaching the periphery. Interradial equatorial thickening with irregular internal boundaries. The size range is 15-25μ.

Remarks:— This species is within the size range of '*Gleichenia*' *minutissima* Malyavkina, 1958, but detailed comparison with that species is not possible on the basis of a single line drawing.

Distribution:— Common form of the pteridophyte-rich associations in Proserpine 1.

Genus CAMAROZONOSPORITES Pant ex Potonié *emend.* Klaus, 1960

Type species:— *Camarozonosporites cretaceus* (Weyland & Krieger) Potonié, 1956.

Camarozonosporites sp.

Plate 2, Figures 14 and 15

Figured specimen:— Slide S 2760, stage co-ordinates 36.7, 102.0, reference point 13.4, 87.5; diameter 35μ.

Locality:— Waterpark Creek N1, 274 ft.

Distribution:— Queensland Tertiary: unit 2 in Aquarius 1, unit 3 in Capricorn 1A, and Waterpark Creek Beds.

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma LAEVIGATOMONOLETI Dybová & Jachowicz, 1957

Genus LAEVIGATOSPORITES Ibrahim, 1933

Type species:— *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1953.

Laevigatosporites major (Cookson) Krutzsch, 1959

Plate 1, Figure 5

Figured specimen:— Slide OD 3826, stage co-ordinates 4.4, 93.4, reference point 13.7, 89.8; diameter 51μ.

Locality:— Aquarius 1, Core 1, 1030 ft.

Distribution:— On the basis of characters discernable with the light microscope this species shows general similarity to forms known from the Carboniferous onwards. The same applies to the smaller species *Laevigatosporites ovatus* Wilson & Webster, 1945. In the Queensland Tertiary both species are common throughout most of the samples examined.

Infraturma SCULPTATOMONOLETI Dybová & Jachowicz, 1957

Genus POLYPODIISPORITES Potonié & Gelletich ex Potonié, 1956

Type species:— *Polypodiisporites favus* (Potonié & Gelletich) Potonié, 1956.

Polypodiisporites sp.

Plate 1, Figures 6, 7, and 10

Figured specimens:— Figure 6—slide OD 3821, stage co-ordinates 36.8, 98.9, reference point 13.5, 85.8; diameter 39μ. Figure 7—Slide OD 3849, stage co-ordinates 8.0, 87.4, reference point 11.9, 86.0; diameter 41μ. Figure 10—Slide OD 3850, stage co-ordinates 30.4, 98.2, reference point 11.9, 89.3, diameter 35μ.

Localities:— Figure 6—Aquarius 1, Core 2, 1506 ft. Figures 7 and 10—Capricorn 1A, Core 1, 1100 ft.

Description:— Anisopolar, bilateral monolete spores, laesurae half to two thirds of the length of the equatorial axis, shape elliptical in polar view, bean shaped in lateral view. Exine 2μ thick, with flat irregular verrucae of *ca.* 1.5-4μ diameter, narrowly arranged and forming a fine negative reticulum of polygonal appearance. Radial arrangement of elongated verrucae towards the laesurae. Size range: 33-45μ.

Remarks:— This species differs from *Polypodiisporites favus* and *Verrucatosporites speciosus* Harris, 1965 in having a radial arrangement of elongated verrucae. *Verrucatosporites speciosus* also has larger verruccae.

Distribution:— Queensland Tertiary: units 4 and 5 in Capricorn 1A, and Aquarius 1.

Genus Polypodiidites Ross, 1949

Type species:— *Polypodiidites senonicus* Ross, 1949.

Discussion:— Although Potonié (1966) incorporated *Polypodiisporites* in the genus *Polypodiidites*, the interpretation of Playford and Dettmann (1965, p. 150) is followed here. They stated that *Polypodiidites* is distinguishable from *Polypodiisporites* in possessing a markedly reduced proximal sculpture. According to Potonié (1966), *Verrucatosporites* Thomson & Pflug, 1953 should be included in *Polypodiidites* Ross, 1949.

Polypodiidites minimus Couper, 1960

Plate 1, Figure 1

Figured specimen:— Slide S 2765, stage co-ordinates 34.5, 99.0, reference point 13.0, 85.6; diameter 28μ.

Locality:— Waterpark Creek N2, 195 ft.

Remarks:— This species is smaller, and has less pronounced verrucae, than *P. usmensis*.

Distribution:— ? Kaiatan (late Eocene) to Awamoan (late Oligocene) in New Zealand (Couper, 1960). Queensland Tertiary: rare throughout the section examined.

Polypodiidites usmensis (van der Hammen) comb. nov.

Plate 1, Figures 8 and 9

partim 1956 *Schizaea papuana* Cookson: p. 44, pl. 7, figs. 10, 12.
1956 *Verrumonoletes usmensis* van der Hammen: p. 116, fig. 7.
1968 *Verrucatosporites usmensis* (van der Hammen) Germeraad, Hopping & Muller: p. 290, pl. 2, fig. 3.

Figured specimens:— Figure 8—Slide OD 3850, stage co-ordinates 34.4, 91.3, reference point 11.9, 89.3, diameter 37μ. Figure 9—Slide OD 3813, stage co-ordinates 30.8, 98.3, reference point 13.8, 88.4; diameter 38μ.

Locality:— Fig. 8—Capricorn 1A, Core 1, 1100 ft. Fig. 9—Aquarius 1, Core 5, 2907 ft.

Remarks:— *P. usmensis* may be a synonym of *P. perverrucatus* Couper, 1953, if specimens with wall thickness of 3μ are to be included. In Couper (1960, pl. 1, fig. 8) a thin walled specimen is shown. The distribution of Couper's species is also similar to that of *P. usmensis*.

Distribution:— Caribbean, Nigeria: from late Eocene; in Borneo from Oligocene onwards (Germeraad, Hopping & Muller, 1968). Range of *P. perverrucatus:* late Oligocene—Miocene (Couper, 1960). Known from the Pliocene of Papua (Cookson, 1956). Queensland Tertiary: typical forms in units 4 and 5 in Capricorn 1A and Aquarius 1.

Affinities:— Compared with the fern genus *Stenochlaena* in Germeraad, Hopping and Muller (1968).

Genus Peromonolites Couper, 1953

Type species:— *Peromonolites bowenii* Couper, 1953.

? *Peromonolites* sp.

Plate 1, Figures 2, 3 and 4

Figured specimens:— Figures 2—Slide OD 3758, stage co-ordinates 28.1, 100.5, reference point 13.0, 86.0; diameter 34μ. Figure 3—Same slide, stage co-ordinates 4.9, 91.4; diameter 34μ. Figure 4—Same slide, stage co-ordinates 28.5, 100.5; diameter 32μ.

Locality:— Capricorn 1A, S.W.C. 3300 ft.

Description: Bilateral, bean shaped monolete spore. Exine 0.5-1μ thick, outer layer consisting of scattered polygonal verrucae and grana of 1-2μ diameter. When overoxidised the outer layer disintegrates and the spore has the appearance of *Laevigatosporites*. Size range: 30-40μ.

Remarks:— Although this species does not have a sculptured inner layer, it is tentatively described under *Peromonolites*.

Affinities:— A species of *Drynaria* (Polypodiaceae) figured by Erdtman (1957, fig. 105) shows morphological similarities.

Distribution:— Restricted to the lignitic section of Capricorn 1A, (unit 3).

Anteturma Pollenites Potonié, 1931

Turma Saccites Erdtman, 1947

Subturma Disaccites Cookson, 1947

Bisaccate pollen grains have not been classified in detail. Only few figures are given as examples of the variety of grains of this type.

Genus Dacrydiumites Cookson, 1953

Type species:— *Dacrydiumites florinii* Cookson & Pike, 1954.

Dacrydiumites sp.

Plate 1, Figure 12

Figured specimen:— Slide OD 3750, stage co-ordinates 4.2, 102.5, reference point 12.1, 86.6; diameter 36μ.

Locality:— Capricorn 1A, S.W.C. 3585 ft.

Distribution:— Rare, throughout all units.

Genus PODOCARPIDITES Cookson, 1947

Type species:— *Podocarpidites ellipticus* Cookson, 1947

Podocarpidites spp.

Plate 1, Figures 11 and 15

Figured specimens:— Figure 11—Slide OD 3759, stage co-ordinates 34.3, 91.8, reference point 13.5, 86.4; diameter 38μ. Figure 15—Slide OD 3774, stage co-ordinates 33.9, 93.0, reference point 14.0, 85.3; diameter 87μ.

Localities:— Figure 11—M.O.P.S. 5, 376 ft. Figure 15—Mackenzie seismic shothole H17, 180-195 ft.

Distribution:— Common in some samples; present throughout all units.

Turma ALETES Ibrahim, 1933

Subturma AZONALETES Luber *emend.* Potonié & Kremp, 1954

Smooth alete forms were not differentiated in detail. They are common in some of the preparations.

Infraturma GRANULONAPITI Cookson, 1947

Genus ARAUCARIACITES Cookson, ex Couper, 1953

Type species:— *Araucariacites australis* Cookson, 1947

Finely granulate alete forms are common throughout the samples studied.

Genus DILWYNITES Harris, 1965

Type species:— *Dilwynites granulatus* Harris, 1965

Dilwynites granulatus Harris, 1965

Plate1, Figure 16

Figured specimen:— Slide OD 3761, stage co-ordinates 33.5, 91.0, reference point 12.8, 88.7; diameter 51μ.

Locality:— M.O.P.S. 5, 376 ft.

Remarks:— Considerable variation of size and shape of the sculptural elements is observed within this species.

Distribution:— Paleocene of Southern Australia (Harris, 1965). Common throughout the units studied.

Turma PLICATES Naumova *emend.* Potonié, 1960

Subturma MONOCOLPATES Wodehouse, Iverson and Troels—Smith 1953

Genus ARECIPITES Wodehouse, 1933

Type species:— *Arecipites punctatus* Wodehouse, 1933.

Arecipites sp.

Plate 3, Figure 11

Figured specimen:— Slide OD 3830, stage co-ordinates 0.3, 100.5, reference point 13.8, 87.8; diameter 40 μ.

Locality:— Aquarius 1, Core 6, 3444 ft.

Remarks:— The generic differentiation of the monocolpate group of Anderson (1960) could not be applied to the Queensland material because the latter is not suitably preserved. Simple monocolpate forms are observed in the size range of 15-40μ.

Distribution:— Relatively rare in units 1 to 4.

Genus LILIACIDITES Couper, 1953

Type species:— *Liliacidites kaitangataensis* Couper, 1953.

Liliacidites spp.

Plate 3, Figures 16-19

Figured specimens:— Figure 16—Slide S 2529, stage co-ordinates 2.5, 98.7, reference point 13.2, 88.1; diameter 28μ. Figure 17—Slide OD 3714, stage co-ordinates 30.9, 85.7, reference point 12.4, 85.4; diameter 32μ. Figures 18 and 19—same slide, stage co-ordinates 29.4, 100.0, diameter 27μ.

Localities:— Figure 16—Brisbane NS5, 138 ft. Figures 17-19—Aquarius 1, Core 10, 5081 ft.

Remarks:— Some of the specimens observed have a similar differentiation of the size of the reticulum as *Liliacidites* sp. ind. in Harris (1965, pl. 27, fig. 11).

Distribution:— Rare in units 1 to 4.

Genus SPINIZONOCOLPITES Muller, 1968

Type species:— *Spinizonocolpites echinatus* Muller, 1968.

Spinizonocolpites echinatus Muller, 1968

Plate 3, Figures 20 and 21

Figured specimens:— Figure 20—OD 3714, stage co-ordinates 7.8, 91.6, reference point 12.4, 85.4; diameter excluding spines 46μ. Figure 21—OD 3714, stage co-ordinates 32.8, 88.3; diameter excluding spines 32μ.

Locality:— Both figures—Aquarius 1, Core 10, 5081 ft.

Remarks:— *Monosulcites prominatus* McIntyre, 1965 differs from a narrow interpretation of this species in having rounded ends of the spines.

Distribution:— Upper Cretaceous to Recent (Germeraad, Hopping and Muller, 1968). Queensland Tertiary: units 2 and 3, common in a few samples only in Aquarius 1, Capricorn 1A.

Affinities:— This form corresponds morphologically with the genus *Nypa* with present-day restriction to the mangrove environment (Germeraad, Hopping and Muller, 1968).

Spinizonocolpites perspinosus (Couper) comb. nov.

Plate 3, Figure 22

1953 *Monosulcites perspinosus* Couper: p. 65, pl. 8, fig. 133.

Figured specimen:— Slide OD 3750, stage co-ordinates 5.8, 103.7, reference point 12.1, 86.6; diameter 33μ without spines.

Locality:— Capricorn 1A, S.W.C. 3585 ft.

Description:— Oblate-suboblate, monocolpate grain, Exine 1.5μ thick, endexine 0.5μ, columellae layer 0.5μ. ectexine forms fine reticulum with lumina less than 0.5μ. Spines scattered on tectum, 5-10μ apart, 4-8μ long, broad based (2-2, 5μ), retain same diameter, for about half their length, then taper sharply to a point. Size range 33-44μ.

Remarks:— Couper (1953) does not describe the reticulum, but in his drawing a reticulate structure may be seen.

Distribution:— Pliocene of New Zealand (Couper, 1953). Queensland Tertiary: unit 2, rare in Capricorn 1A.

Genus GEMMAMONOCOLPITES Van der Hammen & Garcia, 1965

Type species:— *Gemmamonocolpites gemmatus* Van der Hammen & Garcia, 1965.

Gemmamonocolpites sp.

Plate 3, Figure 23

Figured specimen:— Slide OD 3714, stage co-ordinates 29.5, 94.0, reference point 12.4, 85.4; diameter 37μ.

Locality:— Aquarius 1, Core 10, 5081 ft.

Description:— Anisopolar elongate, monocolpate grain, exine 1.5μ thick, ectexine forming finely reticulate pattern (less than 0.5μ). Gemmae scattered on tectum, 3-5μ apart, 2.5-4μ diameter. Size range: 35-45μ.

Remarks:— *Gemmanonocolpites amicus* Gonzales, 1967 differs in having wider spaced gemmae.

Distribution:— Rare in the lignitic section of Aquarius 1.

Genus MILFORDIA Erdtman, 1960

Type species:— *Milfordia hypolaenoides* Erdtman, 1960

Milfordia sp.

1960 Restoniaceae, Couper: p. 62, pl. 9, figs. 26, 27.

Remarks:— Several specimens with similarities to Couper's forms were observed in the size range of 30-60μ.

Distribution:— From Duntroonian (lower Oligocene) onwards (Couper, 1960). Queensland Tertiary: units 3 and 4 in Aquarius 1.

Subturma TRIPTYCHES Potonié, 1960

Genus TRICOLPITES Cookson *emend.* Belsky, Boltenhagen & Potonié, 1965

Type species:— *Tricolpites reticulatus* Cookson, 1947.

Tricolpites asperamarginis McIntyre, 1968

Plate 4, Figure 11

Figured specimen:— Slide OD 3709, stage co-ordinates 31.7, 100.0, reference point 11.9, 87.8; diameter 21μ.

Locality:— Aquarius 1, Core 11, 5432 ft.

Remarks:— In the variation of this species, forms with smooth and slightly scabrate exines have been included. The irregular colpus margins and a scabrate sculpture in the area around them are typical.

Distribution:— Teurian (Paleocene) of New Zealand (McIntyre, 1968). Queensland Tertiary: units 1 to 4 (Aquarius 1, Capricorn 1A, Narrows N8 and N9).

? *Tricolpites* sp. aff. *T. asperamarginis* McIntyre, 1968

Plate 4, Figure 16

Figured specimen:— Slide OD 3813, stage co-ordinates 33.5, 93.0, reference point 13.8, 88.4, diameter 20μ without projections.

Locality:— Aquarius 1, Core 5, 2907 ft.

Remarks:— Shows projections extending from the central colpal region, suggesting a tricolporate character. It is therefore regarded as distinct from the above species.

Distribution:— Rare in Aquarius 1.

Tricolpites sp. aff. *T. bathyreticulatus* Stanley, 1965

Remarks:— Several prolate to oblate subcircular grains were found with an irregular, subisometric reticulum, lumina about 1-3μ. Size range 17-30μ.

Distribution:— Paleocene of South Dakota (Stanley, 1965). Teurian of New Zealand (McIntyre, 1968). Queensland Tertiary: unit 1 to 3 in Proserpine 1, Plevna Beds, 'lignitic section' of Capricorn 1A.

Tricolpites aff. *coprosmoides* Couper, 1960

Plate 4, Figure 24

Figured specimen:— Slide OD 3750, stage co-ordinates 21.8, 100.1, reference point 12.1, 86.6; diameter 30μ.

Locality:— Capricorn 1A, S.W.C. 3585 ft.

Remarks:— This species differs by its smaller size (28-32μ) from *T. coprosmoides*, which has a size range from 44-55μ.

Distribution:— Teurian of New Zealand (Couper, 1960). Queensland Tertiary: lignitic section of Capricorn 1A and Aquarius 1.

Tricolpites sp. aff. *T. inargutus* McIntyre, 1968

Plate 4, Figure 6

Figured specimen:— Slide OD 3815, stage co-ordinates 29.8, 97.8, reference point 13.0, 88.4; diameter 14μ.

Locality:— Aquarius 1, Core 5, 2907 ft.

Remarks:— Psilate to finely scabrate-reticulate specimens with the size range of 10-15μ, which is below that of *T. inargutus*.

Distribution:— Landonian (Oligocene) of New Zealand (McIntyre, 1968). Queensland Tertiary: this and similar small species are characteristic of unit 4 of Capricorn 1A and Aquarius 1.

'*Tricolpites*' *lilliei* Couper, 1953

Plate 4, Figure 28

Figured specimen:— Slide OD 3684, stage co-ordinates 0.5, 95.5, reference point 12.1, 85.0; diameter 34μ.

Locality:— Capricorn 1A, Core 7, 3686-3704 ft.

Remarks:— Because of the restriction of this species to Cretaceous sediments in New Zealand its presence implies either that these specimens are reworked, or that it ranges into the Tertiary in the Queensland section.

Distribution:— New Zealand: Raukumara (Senonian) to Haumurian (Maestrichtian) (Couper, 1960). Queensland Tertiary: isolated specimens in Proserpine 1, and Capricorn 1A.

Tricolpites sp. aff. *T. reticulatus* Cookson, 1947

Plate 4, Figure 23

Figured specimen:— Slide OD 3640, stage co-ordinates 2.1, 90.5, reference point 13.4, 71.6; diameter 36μ.

Locality:— Proserpine 1, Core 6, 2252 ft.

Distribution:— Miocene of the Kerguelen Archipelago (Cookson, 1947). Queensland Tertiary: unit 1 in Proserpine 1, Narrows and Cape Hillsborough.

Tricolpites thomasii Cookson & Pike, 1954

Plate 4, Figures 19 and 20.

Figured specimens:— Figure 19—Slide S 2765, stage co-ordinates 0.7, 102.8, reference point 13.0, 85.6; diameter 21μ. Figure 20—Slide OD 3681, stage co-ordinates 34.8, 97.0, reference point 12.8, 86.6; diameter 22μ.

Localities:— Figure 19—Waterpark Creek N2, 195 ft. Figure 20—Capricorn 1A, Core 7, 3686-3704 ft.

Distribution:— Eocene to Miocene in southern Australia (Harris, pers. comm.). Queensland Tertiary: unit 2 in the lignitic section of Capricorn 1A, Aquarius 1, Plevna Beds and Waterpark Creek Beds.

Tricolpites sp. aff. *T. thomasii* Cookson & Pike, 1954

Plate 4, Figures 12, 17 and 18

Figured specimens:— Figures 12 and 17—Slide OD 3671, stage co-ordinates 37.1, 94.8, reference point 15.0, 74.1; diameter 19μ. Figure 18—Slide S 2479, stage co-ordinates 32.4, 101.0, reference point 11.0, 86.9; diameter 26μ.

Localities:— Figures 12 and 17—Proserpine 1, Core 4, 1652 ft. Figure 18—Narrows N9, 269 ft.

Description:— Radiosymmetric isopolar, oblate grains. Triangular amb, concave sides, truncate apices, tricolpate, angulaperturate. Colpi 3-7μ deep. Exine 1μ, narrowing towards the colpi. Thin columellae layer in middle of exine. Ectexine between pole and colpi smooth, finely granulate—scabrate between colpi. Size range 18-26μ.

Remarks:— This species differs from *T. thomasii* in having an interradial sculpture which varies from slightly developed to almost imperceptible. Similar forms have been observed in southern Australia (Harris, pers. comm.).

Distribution:— Queensland Tertiary: unit 1—rare in Proserpine 1, Narrows N9.

Tricolpites sp. 1

Plate 4, Figures 26 and 27

Figured specimens:— Figure 26—Slide OD 3758, stage co-ordinates 31.9, 91.2, reference point 13.0, 86.0; diameter 33μ. Figure 27—Slide OD 3684, stage co-ordinates 11.1, 87.1, reference point 12.1, 85.0; diameter 31μ.

Locality:— Both figures—Capricorn 1A, Core 7, 3686-3704 ft.

Description:— Radiosymmetric, isopolar, spheroidal to subprolate grains. Amb rounded, tricolpate, polar area about 1/5 of diameter, colpi show irregular smooth margins, and rounded ends. Exine 2.5-3μ thick, ectexine about 2μ. Polar areas smooth, other areas irregularly reticulate, lumina 0.5-1μ. increasing in size towards the intercolpal regions. Size range 30-34μ.

Distribution:— 'Lignitic section' of Capricorn 1A and Aquarius 1.

Genus PSILATRICOLPITES van der Hammen ex Potonié, 1966

Type species:— *Psilatricolpites psilatus* Pierce, ex Potonié, 1966.

Psilatricolpites sp.

Plate 3, Figure 5

Figured specimen:— Slide OD 3659, stage co-ordinates 12.3, 91.1, reference point 13.2, 72.5; diameter 24μ.

Locality:— Proserpine 1, Core 1, 763 ft.

Remarks:— Prolate and oblate psilatricolpate species are not differentiated and could be observed throughout the units studied.

Subturma POLYPTYCHES Potonié, 1960

Genus NOTHOFAGIDITES Erdtman ex Potonié, 1960

Type species:— *Nothofagidites flemingii* Couper ex Potonié, 1960.

'*Nothofagus fusca* group' Cranwell, 1939

Remarks:— Typical members of this group make a very small percentage of the species which are found in the Queensland Tertiary.

Affinities:— The majority of the New Zealand and South American living species of *Nothofagus* have pollen of the *fusca* group (Cookson, 1959).

Nothofagidites sp. aff. *N. brachyspinulosa* (Cookson) Harris, 1965

Plate 6, Figure 13

Figured specimen:— Slide OD 3714, stage co-ordinates 31.9, 87.8, reference point 12.4, 85.4; diameter 24μ.

Locality:— Aquarius 1, Core 10, 5081 ft.

Description:— Radiosymmetric, isopolar, oblate grain, 5-7 colpoid apertures, 3-4μ deep. Sides straight to slightly convex, exine 1-1.5μ thick, undifferentiated. Thickened at sides of colpi, not around their interior ends. Spinules short, 1-1.5μ apart, differentiation of sizes (0.5 -0.75μ in polar areas, 0.3-0.5μ in equatorial areas).

Because of a polar depression, equator and poles can be nearly in the same plane of focus. Size range 24-28μ.

Remarks:— Typical *N. brachyspinulosa* has not only a thickened wall of the colpi in equatorial focus, but also thickening around their interior ends showing a broad U-shaped rim in polar view. Additionally the original species is generally larger than the Queensland specimens.

Distribution:— Queensland Tertiary: few specimens in units 3 and 4 of Capricorn 1A, Aquarius 1 and Plevna Beds.

Nothofagidites sp. aff. *N. waipawaensis* (Couper, 1960) comb. nov.

Plate 6, Figures 7 and 8

1960 *Nothofagus waipawaensis* Couper: p. 55, pl. 7, fig. 27, 28.

Figured specimen:— Figure 7—Slide OD 3641, stage co-ordinates 30.6, 89.4, reference point 13.5, 71.5; diameter 23μ. Figure 8—Slide OD 3657, stage co-ordinates 4.8, 90.7, reference point 12.6, 88.5; diameter 22μ.

Locality:— Figure 7—Proserpine 1, Core 6, 2252 ft. Figure 8—Proserpine 1, Core 1, 763 ft.

Description:— Radiosymmetric, isopolar, oblate-peroblate grain, polygonal amb, 5-7 colpoid apertures, 3-5μ deep, sides straight to slightly convex. Between pores wall thickness of 0.5-0.8μ, thickened fully or partly at sides of colpi along their depth, but not around their interior ends. Spinules 0.3-0.7μ long, irregularly distributed over the whole surface. Size range 18-25μ.

Remarks:— The main difference from *N.* aff. *brachyspinulosa* is that there is no size differentiation of the spinules (within the specimen).

Distribution:— Queensland Tertiary: unit 1; occasionally in units 2 and 3 (Proserpine 1, Narrows Beds).

Nothofagidites sp. 1

Plate 6, Figure 14

1953 *Nothofagus* sp. (*fusca* group) Couper: p. 47 fig. 71.

Figured specimen:— Slide S 2457, stage co-ordinates 31.4, 90.1, reference point 12.6, 88.5; diameter 27μ.

Locality:— Hazlewood Creek.

Description:— Radiosymmetric, isopolar oblate grains, 5-7 colpi, subrounded amb, sides convex. Exine interradially 0.5μ thick, up to 1.5μ thick around the colpi. Spinules short, small, 0.5μ or less in length, 1μ apart. Size range 20-30μ.

Remarks:— Similar to *N. flemingii* Couper, 1953, but smaller and with more densely spaced spinules.

Distribution:— Late Eocene to Recent in New Zealand (Couper, 1960). Queensland Tertiary: units 1 to 3, found in Proserpine 1, Narrows N7 and N8, 'lignitic section' of Capricorn and Plevna Beds.

'*Nothofagus menziesii* group' Cranwell, 1939

Nothofagidites suggatei (Couper) comb. nov.

Plate 6, Figure 12

1953 *Nothofagus suggatei* Couper: p. 48, pl. 6, fig. 74.

Figured specimen:— Slide OD 3684, stage co-ordinates 8.7, 88.7, reference point 12.1, 85.0; diameter 23μ.

Locality:— Capricorn 1A, Core 7, 3686-3704 ft.

Remarks:— Couper's size range (31-38μ) is extended down to 20μ to incorporate the Queensland specimens, which are similar in all other features. *N. aspera* Cookson, 1958 is significantly larger (40-60μ).

Distribution:— Waitakian (middle Oligocene) to upper Southland Series (middle Miocene (Couper, 1960)). Queensland Tertiary: units 1 and 2 in lignitic section of Aquarius 1 and Capricorn 1A, Narrows oil bores.

'*Nothofagus brassi* group' Cookson, 1959

Remarks:— This group is the most widespread one in the *Nothofagidites* rich assemblages of the Queensland Tertiary.

Affinities:— The occurrence of living species of *Nothofagus* with pollen of this group is characteristic for tropical highlands in New Guinea and New Caledonia (Cookson, 1952).

Nothofagidites astra (Couper) comb. nov.

Plate 6, Figure 2

1953 *Nothofagus astra* Couper: p. 49, pl. 6, fig. 77.

Figured specimen:— Slide S 2419, stage co-ordinates 38.6, 105.0, reference point 13.3, 80.6; diameter 26μ.

Locality:— Narrows N8, 180 ft.

Remarks:— This species is distinguished from *N. mataurensis* by the following features: exine 0.75-1μ thick, spinules 0.75-1μ, long diameter 1μ, 1-2.5μ apart. Size range 19-30μ. It differs from *N. falcata* in having straight sides.

Distribution:— Middle Eocene to early Miocene of New Zealand (Couper, 1953). Queensland Tertiary: relatively rare in units 1 to 4, Proserpine 1, Capricorn 1A, Aquarius 1, and Narrows bores.

Nothofagidites falcata (Cookson) comb. nov.

Plate 6, Figure 15

1959 *Nothofagus falcata* Cookson: p. 27, pl. 4, fig. 14.

Figured specimen:— Slide OD 3774, stage co-ordinates 8.6, 89.0, reference point 14.0, 85.4, diameter 27μ.

Locality:— Mackenzie Seismic shothole H17, 180-195 ft.

Remarks:— The asymmetric form of *N.falcata* figured here, has been found in one sample only and may be of stratigraphic or ecologic significance.

Distribution:— Eocene to early Miocene (Cookson, 1959). Queensland Tertiary: units 2 to 4 in Capricorn 1A, Aquarius 1, Mackenzie Seismic shot holes, Plevna oil shales.

Nothofagidites mataurensis (Couper) comb. nov.

Plate 6, Figures 1, 3 and 6

1953 *Nothofagus mataurensis* Couper: p. 49, pl. 6, fig. 78; pl. 9, fig. 142.

Figured specimens:— Figure 1—OD 3761, stage co-ordinates 34.0, 90.0, reference point 12.6, 88.5, diameter 23μ. Figure 3—S 2457, stage co-ordinates 5.8, 93.9; diameter 24μ. Figure 6—S 2457, stage co-ordinates 33.1, 97.1, reference point 12.6, 88.5; diameter 22μ.

Localities:— Figure 1: M.O.P.S. 5, 376 ft; figures 3 and 6: Hazlewood Creek

Remarks:— Exine with evenly distributed spinules of 0.3-0.5μ, 0.5-1μ apart. Although Couper (1960) united *N. astra* with *N. mataurensis* it is considered preferable to separate them, on the basis mainly of differences in the distribution and the size of the spinules.

Distribution:— Bortonian (late Eocene) to Waitotaran (late Pliocene) of New Zealand (Couper, 1960); Eocene to early Miocene of Australia (Cookson, 1959). Queensland Tertiary: units 1 to 4 (most common form of *Nothofagidites*).

Nothofagidites sp. 2

Plate 6, Figures 4, 5, 9, and 10

partim 1946 *Nothofagus* sp. d. Cookson: pl. 1, fig. 19 only (may be subspheroidal after photo).

Figured specimens:— Figures 4 and 5—Slide OD 3710, stage co-ordinates 4.5, 103.7, reference point 11.9, 88.5; diameter 20μ. Figures 9 and 10 —same slide, stage co-ordinates 9.9, 97.3; diameter 22μ.

Locality:— Aquarius 1, Core 11, 5423 ft.

Description:— Radiosymmetric, isopolar, suboblate to spheroidal grains, polar axis 10-15μ. Polygonal amb with straight to (mostly) concave sides and even wall thickness of 1-1.5μ. Colpoid apertures 5-6μ. Spinules irregularly distributed, 1.5-3μ apart, 0.5-1μ thick and about 1μ long. Size range 18-23μ.

Remarks:— This form is similar to fig. 23 and 24 of *N. senectus* Dettmann & Playford, 1968, but it has concave sides. The general aspect of *N.* sp. 2 (with concave sides) is similar to *N. falcata* Cookson, the main difference being the long polar axes of the former.

Distribution:— Queensland Tertiary: units 2 and 3 in Aquarius 1, Capricorn 1A, Mackenzie seismic shotholes, and Plevna oil shales.

Nothofagidites sp. 3

Plate 6, Figure 11

Figured specimen:— Slide S 2459, stage co-ordinates 2.5, 96.2 reference point 13.7, 87.6; diameter 25μ.

Locality:— Hazlewood Creek.

Description:— Radiosymmetric, isopolar, subspheroidal grains. Wall thickness about 0.5μ. Six to eight colpoid apertures, about 5μ long and 0.5μ wide. Spinules evenly distributed, about 0.5μ thick and 1μ and less apart. Size range 23-28μ.

Remarks:— Because of the thin wall and the spheroidal form, obliquely compressed specimens are common.

Genus RETISTEPHANOCOLPITES Leidelmeyer, 1966

Type species:— *Retistephanocolpites angeli* Leidelmeyer, 1966.

Retistephanocolpites sp. aff. *R. reticulatus* (Couper) comb. nov.

Plate 6, Figures 16-20

1960 *Polycopites reticulatus* Couper: p. 63, pl. 10, figs. 6 and 7.

Figured specimens:— Figures 16, 17—Slide OD 3704, stage co-ordinates 32.0, 100.5, reference point 11.9, 87.8; diameter 15μ. Figure 18—Slide OD 3684, stage co-ordinates 34.7, 100.0, reference point 12.1, 85.0; diameter 19μ. Figures 19, 20—Slide OD 3691, stage co-ordinates 33.2, 47.5, reference point 11.8, 88.4; diameter 20μ.

Localities:— Figures 16 and 17—Aquarius 1, Core 11, 5423 ft. Figure 19—Capricorn 1A, Core 7, 3686-3704 ft. Figures 19, 20—Capricorn 1A, Core 5, 2877 ft.

Description:— Radiosymmetric, isopolar, oblate-peroblate grain with mostly 6, probably colpoid apertures. Circular amb, exine 0.5-1μ thick, ectexine 0.25- 0.5μ slightly thickened in colpal areas. Endexine slightly smaller than ectexine in intercolpal areas, strongly thickened in colpal areas. Ectexine reticulate, lumina 0.5-2μ in polar areas, decreasing towards equator. Size range 14-22μ.

Remarks:— *Polycolpites reticulatus* has a size range of 25-28μ (Couper 1960, p. 63).

Distribution:— *P. reticulatus:* late Miocene to Pliocene of New Zealand (Couper, 1960). *P.* aff. *reticulatus* in Queensland Tertiary: units 2 and 3 in Capricorn 1A and Aquarius 1.

Subturma PTYCHOTRIPORINES Potonié, 1960

Genus ILEXPOLLENITES Thiergart, 1937

Type species:— *Ilexpollenites iliacus* (Potonié) Thiergart, 1937.

Ilexpollenites sp.

Plate 3, Figure 6

Figured specimen:— Slide S 2419, stage co-ordinates 0.6, 86.5, reference point 13.3, 80.6; diameter 40μ.

Locality:— Narrows N8, 180 ft.

Description:— Radiosymmetric, isopolar prolate grains, tricolpate, pore indistinct. Exine 2-3μ thick, sculptured with clavae, 1.5-2μ in diameter. Size range 33-45μ.

Remarks:— A similar species is known from the Eocene of southern Australia (W. Harris, pers. comm.).

Distribution:— Queensland Tertiary: units 1 and 2 in Proserpine 1, Narrows bores and Aquarius 1.

'TRICOLPORITES'

Remarks:— Tricolporate, reticulate forms which do not have the properties of *Retitricolporites* (emended, this paper) are provisionally incorporated in this informal group. Possibly previously introduced genera such as *Rhoipites* Wodehouse, 1933 or *Caprifoliipites* Wodehouse, 1933 could be extended in scope to incorporate simple 'retitricolporate' forms, but such taxonomic changes are beyond the scope of this paper.

'Tricolporites' microreticulatus Harris, 1965

Plate 3, Figures 7 and 8

Figured specimens:— Figure 7—Slide OD 3708, stage co-ordinates 4.3, 99.1, reference point 11.4, 91.2; diameter 27μ. Figure 8—Slide OD. 3691, stage co-ordinates 27.1, 99.9, reference point 11.8, 88.4; diameter 21μ.

Localities:— Figure 7—Aquarius 1, Core 11, 5423 ft. Figure 8—Capricorn 1A, Core 5, 2877 ft.

Remarks:— Forms included in this species are those with the proportions of ectexine to endexine from 1:1 to 2:1.

Distribution:— Early Tertiary sediments of southern Australia and the Great Artesian Basin (Harris, 1965). Queensland Tertiary: unit 1 to unit 4, common at most localities.

'Tricolporites' sp. 1

Plate 4, Figure 29

Figured specimen:— Slide OD 3684, stage co-ordinates 34.5, 93.2, reference point 12.1, 85.0; diameter 31μ.

Locality:— Capricorn 1A, Core 7, 3686-3704 ft.

Description:— Radiosymmetric, isopolar subprolate to spheroidal grains. Amb rounded to subtriangular. Polar area about 1/5 of diameter. Tricolporate, colpi with rounded ends, smooth to slightly ornamented margins, which are equatorially thickened. Exine about 2-3μ thick, ectexine slightly thicker than endexine, reticulate, lumina of subcircular appearance, 0.5 to less than 1μ in diameter. Size range 28-35μ.

Remarks:— A very similar species is found in southern Australia from Middle Eocene onwards (W. Harris, pers. comm.).

Distribution:— Lignitic section of Capricorn 1A and Aquarius 1.

Genus RETITRICOLPORITES van der Hammen ex van der Hammen & Wymstra, 1965 *emend.*

partim 1956 *Retitricolporites* van der Hammen, p. 93.

partim 1964 *Retitricolporites* van der Hammen ex van der Hammen & Wymstra, p. 235.

Emended Diagnosis:— Reticulate, tricolporate, prolate to subspheroidal pollen grains. Ectexine with a reticulum with lumina decreasing progressively in size towards the colpi.

Type species:— *Retitricolporites guianensis* van der Hammen & Wymstra 1964.

Other species:— *R. craceus* Gonzalez, 1967;
R. profundus Gonzalez, 1967;
R. byfieldensis sp. nov.

Remarks:— This genus was originally established for 'retitricolporate' forms in general. However, either *Rhoipites* (Wodehouse, 1933) or *Caprifoliipites* (Wodehouse, 1933) would probably have priority for incorporating generalized 'retitricolporate' forms. The separation of the forms with lumina decreasing in size towards the colpi seems to be useful for purposes of morphographic subdivision.

Similar genera:— *Bombacacidites* Couper, 1960 comprises retitricolporate species with lumina decreasing in size from polar and colpal areas towards intercolpal direction (i.e. in reverse compared with the emended genus). *Margocolporites* Ramanujam, 1966 comprises species with a sharply delineated, differentiated structure along the colpi.

Retitricolporites byfieldensis sp. nov.

Plate 3, Figures 12 — 14

Holotype:— Figure 12—Slide S 2647, stage co-ordinates 6.2, 103.0, reference point 11.6, 86.9; diameter 28μ.

Figured specimens:— Figure 13—same slide, stage co-ordinates 26.9, 86.8; diameter 27μ. Figure 14—same slide, stage co-ordinates 26.4, 92.4; diameter 26μ.

Locality:— (all above specimens) Tomahawk Creek, 300 ft. east of junction with Valentine Creek (Waterpark Creek area).

Diagnosis:— Radiosymmetric, isopolar, prolate grain. Tricolporate, long colpi with pointed ends. Exine 1.5-2μ thick, ectexine 1μ, irregularly reticulate. Reticulum coarse in intercolpal areas, muri up to 0.7μ thick, lumina up to 4μ wide, decreasing towards colpal areas. Size range 25-30μ.

Remarks:— The specific name refers to the type locality near Byfield, Queensland. This species differs from the similar species *Retitricolporites guianensis* van der Hammen & Wymstra, 1964, in having smaller dimensions, a greater differentiation in the size of the reticulum, and in having only more or less isometric, instead of longitudinally elongated meshes.

Distribution:— Waterpark Creek lignite (unit 3).

Retitricolporites sp.

Plate 5, Figure 23

Figured specimen:— Slide OD 3750, stage co-ordinates 27.8, 100.1, reference point 12.1, 86.6; diameter 31μ.

Locality:— Capricorn 1A, S.W.C. 3585 ft.

Remarks:— Differs from *R. byfieldensis* in its larger size, more subspheroidal appearance and smaller maximum mesh diameter.

Distribution:— Unit 3 in Waterpark Creek lignite, and unit 2 in lignitic section of Capricorn 1A.

Genus STRIATRICOLPORITES van der Hammen ex Leidelmeyer, 1966

Type species:— *Striatricolporites primulis* Leidelmeyer, 1966.

Remarks:— The type species of this genus *S. primulis* is an oblate form, which is very similar to forms of the genus *Cranwellia* (Srivastava, 1966). It may turn out to be useful to separate prolate forms of this group, like *S. minor*.

Striatricolporites minor Muller, 1968

Plate 3, Figures 2, 4

Figure specimens:— Figure 2—Slide S 2529, stage co-ordinates 3.7, 98.3, reference point 13.2, 88.1; diameter 27μ. Figure 3—Slide S 2531, stage co-ordinates 27.4, 96.5, reference point 11.5, 87.0; diameter 26μ. Figure 4—Slide S 2419, stage co-ordinates 32.2, 87.3, reference point 13.3, 80.6; diameter 29μ.

Localities:— Figure 2—Brisbane NS 5, 138 ft. Figure 3—Brisbane NS 4, 102 ft. Figure 4—Narrows N8, 180 ft.

Remarks:— Pollen grains with pores practically imperceptible have been included in this species. Variations occur in thickness of the surface structure and in the intervals between the striations.

Distribution:— Rare in *Araucariacites* and *Rugubivesiculites* zones (late Cretaceous) of Borneo, common in the higher zones (Muller, 1968). Queensland Tertiary: units 1 to 4, common in Corinda and Sunnybank Formation (Brisbane area), rare throughout the majority of the samples.

? *Striatricolporites* sp.

Plate 3, Figure 1

Figured specimen:— Slide S 2529, stage co-ordinates 11.3, 107.7, reference point 13.2, 88.1; diameter 32μ.

Locality:— Brisbane NS 5, 138 ft.

Remarks:— The assignment of this species to *Striatricolporites* is provisional because the 'striations' differ in structure from those of typical representatives of the genus. They consist of pointed ridges of 1-1.5μ width and 4-5μ length, which are orientated meridionally.

Distribution:— Unit 1: Corinda Formation (Brisbane area).

Genus PSILATRICOLPORITES van der Hammen, 1956 ex van der Hammen & Wymstra, 1964

Type species:— *Psilatricolporites operculatus* van der Hammen & Wymstra, 1964.

Remarks:— Further study is needed to determine whether *Cupuliferoipollenites* Potonié, 1951 is a more specialised genus, or an older name for *Psilatricolporites*.

Psilatricolporites operculatus van der Hammen & Wymstra, 1964

Plate 4, Figure 5

Figured specimen:— Slide OD 3826, stage co-ordinates 29.5, 98.5, reference point 13.7, 89.8; diameter 16μ.

Locality:— Aquarius 1, Core 1, 1030 ft.

Distribution:— From Eocene-Oligocene onward in Borneo, Nigeria, and the Caribbean area (Germeraad, Hopping and Muller, 1968). Queensland Tertiary: rare in unit 5 (Pliocene) of Aquarius 1.

Psilatricolporites spp.

Remarks:— Simple psilatricolporate forms with a size range from 18-30μ have been observed throughout all units.

Genus ZONOCOSTITES Germeraad, Hopping & Muller, 1968

Type species:— *Zonocostites ramonae* Germeraad, Hopping & Muller, 1968.

Zonocostites ramonae Germeraad, Hopping & Muller, 1968

Plate 3, Figures 9, 10 and 15

Figured specimens:— Figure 9—Slide OD 3822, stage co-ordinates 31.3, 87.0; reference point 13.5, 85.8; diameter 26μ. Figure 10—same slide, stage co-ordinates 10.3, 99.0; diameter 21μ. Figure 15—Slide OD 3759, stage co-ordinates 28.3, 105.0, reference point 13.5, 86.4; diameter 17μ.

Localities:— Figure 9 and 10—Aquarius 1, Core 2, 1506 ft. Figure 15—M.O.P.S. 5, 376 ft.

Remarks:— Figure 15 is very similar to *Z. ramonae* while the other two specimens are somewhat larger (original size range 19μ).

Distribution:— From Eocene onward in Caribbean area and Borneo, from Oligocene onward in Nigeria (Germeraad, Hopping and Muller, 1968). Queensland Tertiary: units 1 to 5, but only in M.O.P.S. 5 and Aquarius 1.

Genus ALANGIOPOLLIS Krutzsch, 1962

Type species:— *Alangiopollis barghoornianum* (Traverse) Krutzsch, 1962.

Alangiopollis sp.

Plate 4, Figures 21, 25

Figured specimens:— Figure 21—Slide S 2534, stage co-ordinates 88.7, reference point 13.7, 85.5; diameter 34μ. Figure 25—Slide S 2531, stage co-ordinates 30.4, 96.3, reference point 11.5, 87.0; diameter 35μ.

Localities:—Both specimens—Brisbane NS 4, 102 ft.

Description:— Tricolporate suboblate-spheroidal grains with subcircular amb. Colpi wide, floored with smooth membrane. Exine 3μ thick, with three layers of about equal thickness, all three decreasing towards colpal areas. The columellae layer is in both figures in focus and forms a fine reticulum. Outer layer is radially reticulate to irregularly striate, striae in surface focus anastomosing. Size range 32-40μ.

Remarks:— This species has a surface structure similar to *A. barghoornianum*, but differs from this species by its size range (92 μ in Traverse, 1955). *Alangium javanicildes* Cookson, 1957 has a different surface sculpture.

Distribution:— Restricted to Brisbane NS 4, 102 ft. (unit 1).

Genus ECHITRICOLPORITES van der Hammen ex Germeraad Hopping & Muller, 1968

Type species:— *Echitricolporites spinosus* van der Hammen ex Germeraad, Hopping & Muller, 1968.

Remarks:— *Tubulifloridites* Cookson, 1947, is restricted to species with reduced or imperceptible pores. *Compositoipollenites* Potonié, 1951 is restricted to species with reduced colpi and a negative reticulum. If it should be useful to group these genera in a wider sense, *Compositoipollenites* would have priority, as *Tubulifloridites* was proposed originally as a subgenus. (Article 60 of I.C.B.N.)

Echitricolporites mcneillyi Germeraad, Hopping & Muller, 1968

Plate 4, Figure 1

Figured specimen:— Slide OD 3826, stage co-ordinates 0.7, 97.9, reference point 13.7, 89.8; diameter 14μ.

Locality:— Aquarius 1, Core 1, 1030 ft.

Remarks:— The main difference from *E. spinosus* is in the presence of smaller and less widely spaced spinules.

Distribution:— *Echitricolporites mcneillyi* zone (Pliocene) of the Caribbean area (Germeraad, Hopping, and Muller, 1968). Queensland Tertiary: rare in unit 5.

Echitricolporites sp. aff. *E. spinosus* van der Hammen ex Germeraad, Hopping & Muller, 1968

Plate 4, Figures 2 to 4

Figured specimens:— Figures 2 and 3—Slide OD 3823, stage co-ordinates 31.5, 105.4, reference point 13.7, 87.8; diameter 15μ. Figure 4—same slide, stage co-ordinates 31.4, 103.5; diameter 15μ.

Locality:— All figures—Aquarius 1, Core 1, 1030 ft.

Remarks:— In this species there is a rather large amount of variability in size and in degree of spinosity (Germeraad, Hopping, and Muller, 1968). The Queensland species is compared with it, although the size range is from 14-20μ, somewhat lower than the size of the type material (23μ).

Distribution:— *Echitricolporites spinosus* zone (middle Miocene) in Nigeria, Borneo, and the Caribbean area (Germeraad, Hopping, and Muller, 1968). Queensland Tertiary: units 4 and 5, rare in unit 4 of Aquarius 1, common in unit 5 of Capricorn 1A and Aquarius 1.

Genus CUPANIEIDITES Cookson & Pike, 1954

Type species:— *Cupaniedities orthotheichus* Cookson & Pike, 1954.

Cupaniedities orthotheichus Cookson & Pike, 1954

Plate 4, Figures 7, 8 and 13

Figured specimens:— Figure 7—Slide OD 3684, stage co-ordinates 4.6, 91.2, reference point 12.1, 85.0; diameter 15μ. Figure 8—Slide S 2534, stage co-ordinates 5.3, 89.7, reference point 13.7, 85.5; diameter 20μ. Figure 13—Slide OD 3739, stage co-ordinates 4.7, 105.9, reference point 12.2, 89.7; diameter 26μ.

Localities:— Figure 7—Capricorn 1A, Core 7, 3684-3704 ft. Figure 8—Brisbane NS 4, 102 ft. Figure 13—Aquarius 1, Core 15, 7334 ft.

Distribution:— From Paleocene upwards in southern Australia (Harris, 1965). Queensland Tertiary: units 1 to 3. Rare in most of the samples of these units; not observed in higher units.

Genus MYRTACEIDITES Cookson & Pike, 1954.

Type species:— *Myrtaceidites mesonesus* Cookson & Pike, 1954.

Myrtaceidites eucalyptoides Cookson & Pike, 1954

Plate 4, Figure 15

Figured specimen:— Slide OD 3822, stage co-ordinates 29.6, 98.2, reference point 13.5, 85.8; diameter 16μ.

Locality:— Aquarius 1, Core 2, 1506 ft.

Distribution:— Queensland Tertiary: units 1 to 5.

Myrtaceidites sp. aff. *M. eugeniioides* Cookson & Pike, 1954

Plate 4, Figure 14

Figured specimen:— Slide OD 3653, stage co-ordinates 28.5, 83.3, reference point 15.0, 75.5; diameter 18μ.

Locality:— Proserpine 1, Core 2, 1059 ft.

Remarks:— The figured specimen is above the size range of *M. eugeniioides* (9-14μ) and does not have the typical sunken pores of this species.

Distribution:— Eocene-Pliocene (Cookson and Pike, 1954). From *M. eugeniioides* zone (late Paleocene) of Victoria onwards (Harris, 1965). Queensland Tertiary: throughout all units.

Myrtaceidites parvus Cookson & Pike, 1954

Plate 4, Figure 9

Figured specimen:— Slide OD 3706, stage co-ordinates 29.1, 97.3, reference point 10.4, 87.4; diameter 12μ.

Locality:— Aquarius 1, Core 12, 5776 ft.

Distribution:— Eocene-Pliocene (Cookson and Pike, 1954). Queensland Tertiary: throughout all units, rare in most samples.

Turma Poroses Potonié, 1960

Subturma Monoporines Potonié, 1960

Genus Restoniidites Elsik, 1968

Type species:— *Restoniidites hungaricus* (Kedves) Elsik, 1968.

Restoniidites homeopunctatus (McIntyre) Elsik, 1968

Plate 6, Figure 30

Figured specimen:— Slide OD 3714, stage co-ordinates 34.8, 86.5, reference point 12.4, 85.4; diameter 37μ.

Locality:— Narrows N8, 180 ft.

Remarks:— The Queensland specimens are generally thinner walled than in the original description. A rim of 2μ around the pore is often only faintly visible in unstained material.

Distribution:— Miocene of New Zealand (McIntyre, 1965). From middle Eocene onwards in southern Australia (Harris, 1970). Queensland Tertiary: units 1 to 3 in Narrows bores, Mackenzie seismics hotholes, 'lignitic section' of Capricorn 1A, and 'lower marine section' of Aquarius 1.

Genus Monoporites Cookson ex van der Hammen, 1954

Type species:— *Monoporites media* Cookson, 1947. *Monoporites* sp.

Distribution:— In tropical areas from the *Monoporites annulatus* zone (middle Eocene) upwards (Germeraad, Hopping, and Muller, 1968). Queensland Tertiary: units 3 and 4, rare and sporadically distributed in Capricorn 1A, and Mackenzie seismic shotholes.

Subturma Triporines Potonié, 1960

Genus Beaupreaidites Cookson, 1950

Type species:— *Beaupreaidites elegansiformis* Cookson, 1950.

Beaupreaidites spp.

Plate 4, Figure 10

Figured specimen:—Slide S 2770, stage co-ordinates 2.0, 103.8, reference point 12.8, 85.5; diameter 19μ.

Locality:— Waterpark Creek N2, 107-109 ft.

Remarks:— This species is below the size range of *B. verrucosus* and the exine around the apertures is of constant thickness or even with irregularly thickened verrucae. In the latter feature it differs from typical species of the genus and consequently this generic assignment is provisional. Other specimens with similarities to *Beaupreaidites* were also below the size range of the known Australian species.

Distribution:— Queensland Tertiary: rare in 'lower marine section' of Aquarius 1 and in Proserpine 1; common in Waterpark Creek bores.

Genus Casuarinidites Cookson & Pike, 1954

Type species:— *Casuarinidites cainozoicus* Cookson & Pike, 1954

Casuarinidites cainozoicus Cookson & Pike, 1954

Plate 5, Figure 5

Figured specimen:— Slide OD 3705, stage co-ordinates 33.1, 91.3, reference point 11.0, 83.2; diameter 22μ.

Locality:— Aquarius 1, Core 12, 5776 ft.

Remarks:— The figured specimen is below the size range of the original species. However, most of the other specimens (not figured) are typical in all features.

Distribution:— From *Triorites edwardsii* zone onwards in southern Australia (Harris, 1965). Queensland Tertiary: units 1 to 5 of Aquarius 1, Capricorn 1A, and Mackenzie seismic shotholes; common in units 4 and 5.

Genus Tiliaepollenites Potonié ex Potonié & Venitz, 1934

Type species:— *Tiliaepollenites instructus* Potonié ex Potonié & Venitz, 1934.

Tiliaepollenites notabilis Harris, 1965

Distribution:— A few specimens of *T. notabilis* were found in unit 1 of Proserpine 1. The presence of one specimen in Cape Hillsborough M.O.P.S. 5, 376 ft. (Oligocene) may suggest a different stratigraphic range for this species in Queensland from its known range in southern Australia, where it is restricted to Paleocene to middle Eocene deposits (Stover, pers. comm.).

Genus Proteacidites Cookson, 1950

Type species:— *Proteacidites adenanthoides* Cookson, 1950.

Remarks:— Rather small specimens are predominant and the genus *Proteacidites* seems to be quantitatively much less important in the Queensland Tertiary than at the same time in southern Australia.

Proteacidites sp. aff. *P. annularis* Cookson, 1950

Plate 5, Figure 18

Figured specimen:— Slide S 2529, stage co-ordinates 30.5, 96.2, reference point 13.2, 88.1; diameter 21μ.

Locality:— Brisbane NS 5, 138 ft.

Remarks:— Similar to *P. annularis*, but below the original size range (27 to 37μ).

Distribution:— Common in the Paleocene of southern Australia (Harris, 1965). Queensland Tertiary: rare in Brisbane NS 5.

Proteacidites sp. aff. *P. crassus* Cookson, 1950

Plate 5, Figures 16 and 20

Figured specimens:— Figure 16—Slide 2523, stage co-ordinates 13.1, 92.3, reference point 13.7, 86.4; diameter 33μ. Figure 20—Slide OD 3654, stage co-ordinates 32.9, 82.8, reference point 14.6, 73.1; diameter 27μ.

Localities:— Figure 16—Brisbane NS 5, 270 ft. Figure 20—Proserpine 1, Core 2, 1059 ft.

Remarks:— Cookson (1950) notes the size of the figured specimen only (58μ) and gives no size range. The Queensland specimens are very similar in other details. When the size range of this species is extended down to 27μ, the latter specimens may be included.

Distribution:— Known from Paleocene onwards in southern Australia (Harris, 1965). Queensland Tertiary: unit 1 in Proserpine 1, Brisbane NS 5.

Proteacidites sp. aff. *P. granulatus* Cookson, 1953

Plate 5, Figure 17

Figured specimen:— Slide OD 3684, stage co-ordinates 34.1, 95.6, reference point 12.1, 85.0; diameter 31μ.

Locality:— Capricorn 1A, Core 7, 3686-3704 ft.

Remarks:— Most of the Queensland specimens are below the size range (32-51μ) of Cookson's species and have a thin exine (about 1μ). The ectexine is thinner than the endexine and is finely scabrate or reticulate.

Distribution:— Queensland Tertiary: units 1 to 4, rare in Capricorn 1A, Aquarius 1, Proserpine 1, and Plevna oil shales.

Proteacidites latrobensis Harris, 1966

Plate 5, Figure 13

Figured specimen:— Slide OD 3714, stage co-ordinates 3.7, 100.6, reference point 12.4, 85.4; diameter 22μ.

Locality:— Aquarius 1, Core 10, 5081 ft.

Distribution:— *Triorites edwardsii* zone upwards in southern Australia (Harris, 1965). Queensland Tertiary: rare in unit 2 of Aquarius 1.

Proteacidites sp. aff. *P. minimus* Couper, 1954

Plate 5, Figure 9

Figured specimen:— Slide OD 3758, stage co-ordinates 31.4, 98.2, reference point 13.0, 86.0; diameter 25μ.

Locality:— Capricorn 1A, S.W.C. 3300 ft.

Remarks:— The figured specimen differs from the type by its unusually thick endexine.

Distribution:— Awamoan (late Oligocene) to lower Nukumaruan (early Pleistocene) of New Zealand (Couper, 1960). Queensland Tertiary: rare in units 2 and 3, Capricorn 1A.

Proteacidites pachypolus Cookson & Pike, 1954

Plate 5, Figure 12

Figured specimen:— Slide S 2419, stage co-ordinates 6.5, 86.9, reference point 13.3, 80.6; diameter 30μ.

Locality:— Narrows N8, 180 ft.

Remarks:— Potonié, 1967, p. 194 suggested that the species would be more appropriately assigned to *Translucentipollis* Khlonova, 1961, which Stanley (1970, p. 14) regards as a synonym of *Fibulapollis* Khlonova, 1961. The latter genus as emended by Stanley 1970 is not considered suitable for *P. pachypolus*, because of the rather different form of the branches and 'colpoid' apertures. The polar projections in *P. pachypolus* are hemispherical and differentiated in wall structure, while in *Fibulapollis* the polar areas gradually merge with the rest of the exine.

Distribution:— *Duplopollis orthotheichus* zone in southern Australia (Harris, 1965). Queensland Tertiary: units 1 to 3, in Capricorn 1A, Aquarius 1, Proserpine 1, Mackenzie seismic shotholes, Plevna oil shales, and Narrows bores.

Proteacidites sp. aff. *P. subpalisadus* Couper, 1953

Plate 5, Figure 8

Figured specimen:— Slide S 2531, stage co-ordinates 34.0, 95.3, reference point 11.5, 87.0; diameter 32μ.

Locality:— Brisbane NS 4, 102 ft.

Remarks:— This species has an irregular reticulum with lumina up to 1μ and thin muri decreasing in size towards the deep concave apertures. The amb and the size are very close to *P. subpalisadus*.

Distribution:— Late Cretaceous to early Oligocene of New Zealand (Couper, 1953). Queensland Tertiary: unit 1 in Brisbane NS 4.

Proteacidites sp. 1

Plate 5, Figures 14 and 19

Figured specimens:— Figure 14-Slide S 2419, stage co-ordinates 34.5, 91.2, reference point 13.3, 80.6; diameter 33μ. Figure 19—Slide S 2523, stage co-ordinates 9.7, 104.7, reference point 13.7, 86.5; diameter 28μ.

Localities:— Figure 14—Narrows N 8, 180 ft. Figure 19—Brisbane NS 5, 270 ft.

Description:— Radiosymmetric isopolar triporate grains, triangular amb, sides straight. Pores 3-5μ wide, exine about 2μ thick. Ectexine thinner than endexine, irregularly reticulate with 0.5 to 1.5μ lumina, size of lumina decreasing towards apertures. Size range 28-40μ.

Remarks:— Similar to *P. asperatus* (McIntyre, 1968). The smaller size range and the reticulate surface structure are the features in which it differs from the former species.

Distribution:— Queensland Tertiary: rare in unit 1 in Narrows N 8 and Brisbane NS 5.

Genus CORSINIPOLLENITES Nakoman, 1965

Type species:— *Corsinipollenites oculusnoctis* (Thiergart) Nakoman, 1965.

Remarks:— Potonié (1967, p. 210) uses the genus *Oculopollis* Weyland & Krieger, 1953 for *C. oculusnoctis.* However the use of a more specialised genus for pollen with morphological features, similar to the recent *Onagraceae* seems to be useful (Traverse, pers. comm.).

Corsinipollenites sp. aff. *C. champlainensis* (Traverse) comb. nov.

Plate 5, Figure 15

1955 *Jussiaea champlainensis* Traverse: p. 66, fig. 12-104.

Figured specimen:— Slide OD 3684, stage co-ordinates 8.7, 102.1, reference point 12.1, 85.0; diameter 48μ.

Locality:— Capricorn 1A, Core 7, 3686-3704 ft.

Remarks:— This species is very similar to *Corsinipollenites oculusnoctis* (Thiergart) Nakoman, 1965. However, in the Queensland specimens long viscid hairs are clearly evident, as in *Jussiaea champlainensis* Traverse, 1955. The only obvious difference is in the size as Traverse quotes a diameter of 85μ for his specimen.

Distribution:— Oligocene of the Brandon formation (Traverse, 1955). Queensland Tertiary: units 2 and 3 in Capricorn 1A, and Waterpark Creek N2.

'TRIORITES'

Remarks:— The name is not used in the sense of the type species *Triorites magnificus* (Cookson). It is used here in the sense of an informal unit for simple triporate forms of plurigene origin and wide intraspecific variations. These are difficult to place within narrowly defined genera.

'Triorites' harrisii Couper, 1953

Plate 5, Figure 7

Figured specimen:— Slide S 2415, stage co-ordinates 1.9, 97.3, reference point 11.1, 84.5; diameter 28μ.

Locality:— Narrow N 8, 300 ft.

Remarks:— Wall thickness and surface structure is highly variable in different states of preservation.

Distribution:— From Teurian (Danian) onwards in New Zealand (Couper, 1960). Known only from Paleocene onwards in southern Australia (Harris, 1965). Queensland Tertiary: common to abundant throughout nearly all samples.

'Triorites' orbiculatus McIntyre, 1965

Plate 5, Figure 6

Figured specimen:— Slide S 2419, stage co-ordinates 28.7, 90.3, reference point 13.3, 80.6, diameter 32μ.

Locality:— Narrows N8, 18 ft.

Remarks:— The Queensland specimens are very close to this species. They only differ in the size range (up to 35μ) which exceeds the size range given by McIntyre (19-27μ).

Distribution:— In New Zealand: Duntroonian (Oligocene) to lower Southland (Miocene) (McIntyre, 1965). Queensland Tertiary: unit 1 to 4 in Proserpine 1, Capricorn 1A, Aquarius 1, Narrows (common), Plevna Beds and Mackenzie seismic shotholes.

Genus SANTALUMINIDITES Cookson & Pike 1954

Type species:— *Santaluminidites cainozoicus* Cookson & Pike, 1954.

Santaluminidites cainozoicus Cookson & Pike, 1954

Plate 5, Figures 10 and 11

Figured specimens:— Figure 10—Slide OD 3657, stage co-ordinates 2.9, 93.4, reference point 10.8, 91.1; diameter 30μ. Figure 11—Slide OD 3759, stage co-ordinates 34.6, 100.0, reference point 13.5, 86.4; diameter 30μ.

Localities:— Figure 10—Proserpine 1, Core 1, 763 ft. Figure 11—M.O.P.S. 5, 376 ft.

Remarks:— This species is comparable with the more or less smooth specimens of Cookson and Pike's species (pl. 2. figs. 67-69). Specimens observed here are smooth, or finely ornamented, without any separation of the wall surface pattern within the exine. Other, differently ornamented species with similar appearance are discussed in Germeraad, Hopping, and Muller (1968).

Distribution:— Early Tertiary onwards (Cookson and Pike, 1954). Queensland Tertiary: rare in units 1 to 3, in Proserpine 1, Narrows bores, M.O.P.S. 5, Plevna oil-shales, and Aquarius 1.

Genus ANACOLOSIDITES Cookson & Pike, 1954

Type species:— *Anacolosidites luteoides* Cookson & Pike, 1954.

Anacolosidites sp.

Plate 5, Figures 1-4

Figured specimens:— Figures 1 and 2—Slide OD 3714, stage co-ordinates 30.5, 88.2, reference point 12.4, 85.4; diameter 17μ. Figure 3—Slide OD 3750, stage co-ordinates 9.5, 101.6, reference point 12.1, 86.6; diameter 19μ. Figure 4—Slide OD 3714, stage co-ordinates 0.2, 92.2; diameter 16μ.

Localities:— Figure 1, 2 and 4—Aquarius 1, Core 10, 5081 ft. Figure 3—Capricorn 1A, S.W.C. 3585 ft.

Description:— Radiosymmetric, isopolar, oblate grains with triangular amb. Sides straight to slightly convex, broadly rounded apices. Tri-diploporate, pores oval, radially elongated about 1 × 2μ. Exine 1-1.5μ, smooth to slightly granulate, thinner at apices. Endexine thinner or about same thickness as ectexine, Size range 16-20μ.

Remarks:— This species differs from other species of *Anocolosidites* in its size range and in its arrangement of the pores. This species is not placed under the tri-diplocolpate' genus *Syndemicolpites* van Hoeken—Klinkenberg ex Potonié, 1966, because in the mature state the pollen have elongated pores and no colpi as they seem to have in the immature state.

Distribution:— A similar species is known from Paleocene deposits in southern Australia (Harris pers. comm.). Queensland Tertiary: units 2 and 3 in Capricorn 1A, Aquarius 1, and Waterpark Creek Beds.

Subturma Polyporines Potonié, 1960

Infraturma Stephanoporiti Potonié, 1960

Genus Haloragacidites Couper, 1953

Type species:—*Haloragacidites trioratus* Couper, 1953.

Haloragacidites sp. aff. *myriophylloides* Cookson & Pike, 1954

Plate 6, Figure 21

Figured specimen:— Slide OD 3714, stage co-ordinates 32.6, 91.0, reference point 12.4, 85.4; diameter 15μ.

Locality:— Aquarius 1, Core 10, 5081 ft.

Remarks:— This species differs from *H. myriophylloides* in having a smaller size range.

Distribution:— Rare in unit 2 of Aquarius 1.

Haloragacidites myriophylloides Cookson & Pike, 1954

Plate 6, Figure 24

Figured specimen:— Slide OD 3826, stage co-ordinates 29.0, 105.0, reference point 13.7, 89.8; diameter 23μ.

Locality:— Aquarius 1, Core 1, 1030 ft.

Distribution:— Pliocene of New Guinea (Cookson and Pike, 1954). Queensland Tertiary: rare in unit 5 of Aquarius 1.

Infraturma Periporiti Potonié, 1960

Genus Malvacipollis Harris, 1965

Type species:— *Malvacipollis diversus* Harris, 1965.

Malvacipollis diversus Harris, 1965

Plate 6, Figures 28 and 29

Figured specimens:— Figure 28—Slide OD 3714, stage co-ordinates 5.8, 90.7, reference point 12.4, 85.4; diameter 25μ (without spines). Figure 29—Slide OD 3684, stage co-ordinates 9.0, 101.6, reference point 12.1, 85.0; diameter 27μ (without spines).

Localities:— Figure 28—Aquarius 1, Core 10, 5081 ft. Fig. 29—Capricorn 1A, Core 7, 3686-3704 ft.

Distribution:— In southern Australia from Paleocene onwards (Harris, 1965). Queensland Tertiary: units 1 to 4, all localities.

Genus Malvacearumpollis Nagy emend. Krutzsch 1966

Type species:— *Malvacearumpollis bakonyensis* Nagy, 1962.

Remarks:— Krutzsch (1966) appears to have misinterpreted the dimensions of the pores in his drawing of *Malvacearumpollis*. The real pore dimensions of *M. bakonyensis* after the observations of Nagy (1962) are about 9μ, while Krutzsch draws pores of 3μ diameter. The only difference from *Malvacipollis* Harris (1965) is in the overall dimensions.

Malvacearumpollis estelae (Germeraad, Hopping & Muller) comb. nov.

Plate 6, Figure 27

1962 *Echiperiporites estelae* Germeraad, Hopping & Muller: p. 318, pl. 10, fig. 1.

Figured specimen:— Slide OD 3750, stage co-ordinates 27.8, 101.5, reference point 12.1, 86.5; diameter 54μ (excluding spines).

Locality:— Capricorn 1A, S.W.C. 3585 ft.

Distribution:— In the Caribbean area from late Eocene onwards. In Nigeria from Oligocene onwards, and in Borneo from the higher part of the early Miocene onwards (Germeraad, Hopping, and Muller, 1968). Queensland Tertiary: unit 3 in Aquarius 1, Capricorn 1A, and Mackenzie seismic shothole A 10.

Genus Parsonsidites Couper, 1960

Type species:— *Parsonsidites psilatus* Couper, 1960.

Parsonsidites sp.

Plate 6, Figure 26

Figured specimen:— Slide S 2419, stage co-ordinates 32.4, 104.4, reference point 13.3, 80.6; diameter 27μ.

Locality:— Narrows N 8, 180 ft.

Remarks:— This species differs from *P. psilatus* Couper, 1960 in having less pronounced thickenings around the pores and in having smaller dimensions. (Couper's species: 30-46μ).

Distribution:— Queensland Tertiary: units 1 and 2 in Narrows bores, Cape Hillsborough, and Capricorn 1A.

Genus CHENOPODIIPOLLIS Krutzsch, 1966

Type species:— Chenopodiipollis multiplex (Weyland & Pflug) Krutzsch, 1966.

Chenopodiipollis sp.

Plate 6, Figures 22 and 23

Figured specimens:— Figure 22—Slide OD 3826, stage co-ordinates 12.4, 92.3, reference point 13.7, 89.8; diameter 18μ. Figure 23—Slide OD 3822, stage co-ordinates 31.5, 98.6, reference point 13.5, 85.8; diameter 18μ.

Localities:— Figure 22—Aquarius 1, Core 1, 1030 ft. Figure 23—Aquarius 1, Core 2, 1506 ft.

Description:— Centro-symmetric, spheroidal, periporate grains. Round pores, diameter about 2μ, centres of the pores 3-5μ apart. Wall about 1μ thick, finely granulate-scabrate surface. Size range 15-20μ.

Remarks:— This species is similar in appearance and size to 'Chenopodiaceae, undifferentiated' in Elsik (1969, pl. 2, fig. 18 only). One of the small species of *Periporopollenites* in Nakoman (1968) could be within the range of variation of this species.

Distribution:— Late Neogene of the northern Gulf of Mexico (Elsik, 1969). Queensland Tertiary: units 4 and 5; rare in unit 4 of Capricorn 1A and Aquarius 1; common in unit 5 of Aquarius 1. Larger forms of this genus are known from the Eocene onwards in southern Australia (Harris, pers. comm.).

Turma JUGATES Potonié, 1960

Subturma POLYADITES Pant, 1954

Genus POLYADOPOLLENITES Thomson & Pflug, 1953

Type species:— Polyadopollenites multipartitus Pflug in Thomson & Pflug, 1953.

Polyadopollenites sp.

Plate 6, Figure 25

Figured specimen:— Slide OD 3729, stage co-ordinates 31.7, 95.0, reference point 12.6, 89.4; diameter 28μ.

Locality:— Capricorn 1A, Core 3, 2100 ft.

Remarks:— This species is similar to, but smaller than *Acacia myriosporites* Cookson, 1954, which has a size range of 37-43μ.

Distribution:— Pliocene deposits in Victoria (Cookson, 1954); Middle-Miocene in the Otway and St. Vincent Basins (Harris, 1970). Queensland Tertiary: units 4 and 5 of Capricorn 1A, and unit 5 of Aquarius 1.

INCERTAE SEDIS

Genus CIRCULISPORITES de Jersey *emend.* Norris, 1965

Type species:— Circulisporites parvus de Jersey, 1962.

Circulisporites spp.

Plate 1, Figures 13 and 14

Figured specimens:— Figure 13—Slide OD 36677, stage co-ordinates 44.1, 101.6, reference point 12.7, 87.6; diameter 30μ. Figure 14—Slide S 2523, stage co-ordinates 0.2, 102.7, reference point 12.7, 87.6; diameter 38μ.

Localities:— Figure 13—Aquarius 1, Core 14, 6830 ft. Figure 14—Brisbane NS 5, 270 ft.

Remarks:— The nomenclature and systematic position of this genus is discussed in de Jersey (1970, p. 19). In the Queensland Tertiary specimens, the equatorial rupture, observed by Norris (1965, p. 261) is indicated by a thinner equatorial zone. The more or less concentric ribs partly anostomose and can be incomplete, forming irregular verrucae towards the polar area. These fossils are considered to be of microplanktonic origin by Norris (1965). Queensland occurrences indicate specialisation in a fresh water environment. Harris (pers. comm.) suggested an origin from fungal spores as an alternative possibility. *Chomotriletes* sp. of Jardine and Magloire (1963, p. 203, pl. 1, figs. 23, 24) from the Albian—Cenomanian from Senegal and the Ivory coast seems to be very similar to some of the Queensland specimens.

Distribution:— Permian of Western Australia (Segroves, 1967); Triassic and Jurassic of Queensland (de Jersey, 1970); Triassic of Antarctica (Norris, 1965); Cretaceous of Africa (Jardine and Magloire, 1963). Queensland Tertiary: units 1 and 2, in Proserpine 1, Aquarius 1, and Brisbane NS 4.

STRATIGRAPHIC DISCUSSION

The section of the petroleum exploration well A.G.O. Aquarius 1 is used as a reference profile for five biostratigraphic units. For the definition of these units a combination of statistic maxima of occurrence of selected pollen groups and first appearance of species, which proved to have stratigraphic significance. has been used. Unfortunately some of these index species are relatively rare and usually found only when a series of samples of a formation is studied.

The ages of units 2 to 5 are established by cross correlation with foraminiferal zones in the Capricorn Basin (Palmieri. 1971). Additional evidence on dating of parts of unit 1 and unit 3 is available from potassium-argon determinations.

In one case (Proserpine 1) cyclic changes in the relative frequencies of groups seem to be useful for subdividing one of these units. Most of these five units are local 'zonules', in the sense of Harris (1971), which may have local use in the Queensland region. Only three of these units can be compared with the more widely recognised zones of Germeraad, Hopping, and Muller (1968).

TENTATIVE CORRELATION CHART OF QUEENSLAND TERTIARY DEPOSITS

Periods	World-wide planktonic zones	Capricorn Basin zones (Palmieri, 1971)	Palynological units	Terrestrial sediments: Moreton Bay area — Brisbane (more than 1100 ft)	Moreton Bay area — Mt. Tamborine (relatively than)	Eastern Central Queensland — Narrows Graben (more than 600 ft)	Hillsborough Basin (up to 10000 ft (G))	Duaringa Basin (up to 3500 ft (G))	Plevna (more than 265 ft)	Waterpark Creek (more than 300 ft)	Area of predominantly Marine sedimentation: Capricorn Basin — Capricorn 1 A (4030 ft.)	Aquarius 1 (8110 ft.)
Pliocene / Middle and Late Miocene	N 21 and N 20	X and IX	V								C 1 F. P.	C 1 F. P.
Middle and Late Miocene	N 19 to N 8	VIII to IV	IV								C 2 to C 4 F. P.	C 2 to C 5 F. P.
Early Miocene	N 7 to N 5	III	III		Sediments underlying basalts (1 sample) NOTH. B.			Duaringa beds interval sampled 500 ft NOTH. P.	Plevna beds (1 Sample) NOTH.	Waterpark creek beds interval sampled 300 ft NOTH. P.	C 5 F. P. NOTH.	C 6 to C 5 F. P. NOTH.
		II										
Late Oligocene	N 4 / N 3	I	II								? SWC 3585-3117 'Lignitic section' C 7 P.	'Lignitic and Lower marine section' C 11-C 10 P.
? Paleocene ? M. Oligocene			I	Sunnybank Fm. Corinda Fm. Darra Fm. NEG. GEOL.		Narrows beds interval sampled 300 ft NEG.	Proserpine beds interval sampled 3400 ft Hillsborough beds interval sampled 400 ft NEG. B.					'Redbed section' C 15-C 12 NEG.

Evidence for above correlations

- NOTH. — Nothofagidites predominance
- F. — Foraminiferal dates
- B. — Basalt dates
- NEG. — Negative evidence from Palynomorphs
- P. — Palynomorphs with index value
- GEOL — Other stratigraphic evidence

Figure 2

UNIT 1

(Lower Tertiary undifferentiated)

Capricorn Basin:— The 'redbed section' of Aquarius 1 is used as reference section for this unit. This informal term is used for the lower terrestrial section of this well (see fig. 9). Previous palynological reports (Paten, *in* Carlsen and Wilson, 1968) suggested a late Cretaceous age for the 'redbed section'. Above the 'redbed section', in the 'lower marine section', absolute dating of glauconite samples from core 11 (5425 feet) revealed an age of 67.1 million years, which would correspond with the Upper Cretaceous after the time scale in Berggren (1969). However, the relative consistency of the pollen flora and nannofossil assemblages of the cuttings suggest no major break of sedimentation above the 'redbed section'. Arguments for an Oligocene age of the 'lower marine section' are summarized later (see unit 2). In this paper, further evidence for an age younger than Cretaceous for the 'redbed section' is provided by species of *Myrtaceidites*, *Cupanieidites*, and *Nothofagidites*.

The glauconites with Cretaceous absolute age can be interpreted as reworked, since the petrographic report in Carlson and Wilson (1968) decribes the glauconite grains as rounded and polished.

No further evidence has been found till now for more detailed age definition, than from Paleocene to middle Oligocene, for the 'redbed section' and the palynological unit 1.

Microfloral assemblages of similar aspect are found in the Hillsborough Basin, the Narrows area and the Brisbane area. Except the early Oligocene potassium-argon dates of Cape Hillsborough (McDougall and Slessar, in prep.), they are not dated by evidence other than pollen assemblages. These can only be assigned to the interval between Paleocene and Oligocene on the basis of negative evidence. Correlation between these individual deposits and with the reference section is therefore uncertain.

Characteristic palynomorphs for unit 1 are *Cupanieidites orthotheichus*, *Malvacipollis diversus*, *Myrtaceidites eugeniioides*, *M. parvus*, *Nothofagidites mataurensis*, *N.* sp. aff. *N. waipawaensis*, *Polypodiaceoisporites* sp. aff. *P. retirugatus*, *Straitricolporites minor*, *'Triorites' harrisii*, and *'T'. orbiculatus*. The relative proportions of spores and angiosperm pollen have local significance. None of these species is restricted to unit 1.

Hillsborough Basin:— In Proserpine 1, a section of 4,250 feet of silty shales, interbedded with minor sandstone and tuffaceous sediments, was penetrated. Only palynological evidence on the age is available.

In a previous study Evans (*in* Ampol, 1965) examined the cores for pollen and spores and found a "low yield of pteridophytic spores and minor amount of angiosperms with few *Nothofagidites*". In his age interpretation he gave three possibilities:—

1. Restricted local facies
2. Negative evidence for relatively late Tertiary age (absence of the abundant *Nothofagidites* flora generally known from Eocene to Miocene).
3. Dominance of pteridophytes and rarity of *Nothofagidites* could indicate late upper Cretaceous, but no typical upper Cretaceous pollen has been found.

In the present study all samples with the exception of cores 9, 11, and 12 yielded microfloras, which were mostly poorly preserved, and only oxidation for periods up to one hour made it possible to concentrate enough sporomorphs for counting 100 to 200 grains.

From comparison with the zonal scheme of Harris (1971) in South Australia, the similarity of the assemblages to those of the *Cupaniedites orthotheichus* zonule would indicate a Paleocene to early Eocene age. However, most of the pollen species used for this interpretation make their first appearance in South Australia in the Paleocene, but are not restricted to it. Species like *Tiliaepollenites notabilis* and *Nothofagidites* sp. aff. *N. waipawaensis*, first thought to be restricted to the Paleocene, are now known to range into strata at Cape Hillsborough dated by radiometric evidence as Oligocene (McDougall and Slessar, in prep.) L. E. Stover (pers. comm.) states that *T. notabilis* is known to occur in late Paleocene, early and middle Eocene in southern Australia.

It seems likely that the section at Cape Hillsborough was connected with the sediments around Proserpine, but further field evidence on the relationship of the sections is required.

The environment of deposition seems to be mainly terrestrial. The only suggestion of marine or brackish conditions is the record of dinoflagellates in cores 1 and 2 by Evans (*in* Ampol, 1965). Cuttings from the part above core 1 show glauconite and would also indicate marine or estuarine conditions if not derived from reworked sequences. Conclusive evidence for marine incursions was not obtained as foraminifera and nannofossils were not found in the cores and cuttings.

Excluding the possibility of very slow evolution of the flora, the impossibility of subdividing the pollen sequence into more than one pollen 'unit' from core 10 to core 1 suggests the deposition of a major part of the section in a comparatively small time interval. If so, major contemporaneous subsidence would be postulated.

The distribution of major plant groups in the profile shows two cycles of alternating predominance of pteridophytes and angiosperms (see Figure 3). Core 10 shows a pteridophyte peak which steadily decreases to core 6, giving place to an angiosperm peak. With core 4 a maximum of pteridophytes recurs, decreasing again to core 2.

In interpreting this diagram, it first seemed to be connected with the volcanic history of the region, since cores 12 to 8 are described as rich in volcanic fragments (Ampol, 1965). However Ridley (pers. comm.) has made X-ray diffractometer tests for clay minerals from the samples containing predominance of either angiosperms or pteridophytes. The results show a correlation of pteridophyte maxima with an association of kaolinite and montmorillonite in about equal parts. The angiosperm maxima correlated with predominance of montmorillonite. Consequently the first group of samples, from

their mineral composition, appears to have been derived from deeply leached soils in a moist environment. The second group of samples appears to have originated in a dry environment, with less leaching of the soil.

Recent Departmental stratigraphic drilling in the Hillsborough Basin has provided material for more detailed study of the microfloras. It should provide evidence on the relationship of the section at Cape Hillsborough to the sediments in the Proserpine area and on the age of the youngest sediments in the latter area.

Narrows area:— Earlier stratigraphic drilling by the Department of Mines has proved a thickness in excess of 300 feet of Tertiary sediments containing oil shales (Ball, 1946). The sediments contain ostracods, fish and reptilian remains, dicotyledonous plants, and freshwater gastropods. Study of the ostracods revealed a fauna of mostly terrestrial aspect, and a 'Miocene or Neogene age' has been suggested (Beasley, 1945).

The pollen flora is predominantly composed of angiosperms, '*Triorites*' *orbiculatus* being a typical element. There is no evidence for correlation with units later than unit 1.

Brisbane area:— From the re-evaluation of the palynological studies of Harris (1965) and Dempsey and Urban (1965) no further evidence for closer age interpretation than Paleocene to Oligocene is achieved. None of the assemblages can be compared with higher units than unit 1. Independent indications for a pre-Miocene age are provided by the older aspect of the Tertiary volcanics in the Brisbane area and by their topographic relationship to the upper Main Range Volcanics. Absolute mineral dates (Webb, Stevens, and McDougall, 1967) from the latter show a predominance of early Miocene dates (19-24 $\times$ 10^6 years). Sediments close to dated basalts from Mount Tamborine show predominance of *Nothofagidites* (Harris, 1965), which is typical of other Queensland early Miocene deposits (see unit 3).

UNIT 2

(Late Oligocene)

The reference section for unit 2 is the 'lower marine' and the 'lignitic' sections of Aquarius 1. The 'lower marine section' was regarded as lowermost Tertiary by Carlsen and Wilson (1968), because of glauconite datings. As indicated above, these glauconite occurrences are regarded as due to reworking.

More recent evidence for the age of this section is based on reworked foraminifera (Palmieri, in prep.) and nannofossils present in cuttings only (Hekel, in prep.). Cuttings showed consistently Oligocene nannofossils in this section, while below 5730 feet all examined samples were barren. Although no nannofossils have been found in the cores, presumably because of adverse lithological conditions, it seems likely that the examined cuttings are not derived from caving, but are more or less representative of a part of the lower marine section.

Characteristic palynomorphs, not observed in unit 1 are: *Corsinipollenites* sp. aff. *C. champlainensis*, *Graminidites* sp., *Retistephanocolpites* sp., *Spinizonocolpites* sp., *Tricolpites thomasii*, and *Zonocostites ramonae*. Two of these genera, *Spinizonolpites* and *Zonocostites*, are regarded as indicative of a coastal environment. *Corsinipollenites* sp. aff. *C. champlainensis* is not known before the Oligocene. Most of the other taxa are known from Eocene onwards in South Australia (Harris, pers. comm.) For the samples assigned to unit 2 a low percentage of *Nothofagidites* is typical.

In Capricorn 1A, the lower part of the 'lignitic section', core 7, is assigned to unit 2.

UNIT 3

(Early Miocene)

The reference section for unit 3 is the interval from the upper part of core 7 to core 6 of Aquarius 1. This part is dated by Palmieri (1971) as equivalent to zones N4 to N7.

Characteristic palynomorphs not observed in unit 2 are *Crassoretitriletes vanraadshooveni* and *Malvacearumpollis estelae*. The first species is considered to have 'pantropical' index value and is found from early Miocene onwards. The second species has index value for the early Miocene of Borneo and is known earlier from Nigeria and the Carribean area (Germeraad, Hopping, and Muller, 1968).

The peak of *Nothofagidites* seems to be the most typical feature of this zone and it is thought to be a unique event for the Queensland region in the Tertiary. The living genus *Nothofagus* is restricted to humid temperate areas and to montane regions in the tropics (New Caledonia, New Guinea). While the fossil record in southern parts of Australia and New Zealand shows generally high numbers of *Nothofagidites* over a large part of the Tertiary, this genus seems to be abundant only for a shorter interval in Queensland.

Two possible explanations of this abundance are suggested— either a general temperature decline or a time of regional elevation of this area. For the upper part of the the early Miocene only, a temperature decline is suggested by paleotemperature measurements in Victoria (Gill, 1968) and New Zealand (Devereux, 1968). On the other hand, an elevation of the eastern highlands is expected to be in correlation with the subsidence of the Coral Sea platform (Ewing, Hawkins, and Ludwig, 1970). Tropical highland conditions could also be in accordance with the predominance of the *N. brassi* group in the Queensland material.

Capricorn Basin:— Unit 3 covers core 6 and the upper part of core 7 of Aquarius 1, S.W.C. 3585 ft. to core 5 of Capricorn 1A, and Wreck Island, core 11.

Waterpark Creek area:— Lignitic sediments over 300 feet thick are known at Waterpark Creek, 40 miles northeast of Rockhampton. From the occurrence of *Crassoretitriletes vanraadshooveni* and abundance of

COMPARISON OF THE QUEENSLAND TERTIARY WITH SOUTHERN AUSTRALIA AND OVERSEAS MICROFLORAL SEQUENCES

New Zealand microfloras (Couper, 1960)	Southern Australian Zonules (Harris, 1970)	Periods	Foraminiferal Zones (Palmieri, 1971)	Queensland Tertiary palynological units	Pantropical Zones (Germeraad, Hopping & Muller, 1968)	Caribbean Zones (Germeraad, Hopping & Muller, 1968)
Lower Wanganui	Grange Burn flora	Pliocene	N20 and N21	V	Echitricolporites spinosus	Echitricolporites mcneillyi
Taranaki series		Late and Middle Miocene	N15–N19	IV		Pachydermites diederixi
			N14			
			N9–N13	↑ first Polyadopollenites ('Acacia') in N14		
	first 'Acacia in N8		N8			
Southland series	Cyathidites annulata	Early Miocene	N4 – N7	III	Crassoretitriletes vanraadshooveni	Grimsdalea magnaclavata / Multimarginites vanderhammeni
Pareora series	Verrucatosporites sp.	Late Oligocene	N3	II	Magnastriatites howardii	Psiladiporites minimus / Jandufuria seamrogiformis
		?M. Oligocene ? Paleocene		I		

Figure 3

Nothofagidites spp. they are assigned to unit 3 and may be diachronous facies equivalents of the lignitic section of the offshore wells.

Duaringa area:— From the Duaringa area, 3500 feet of Tertiary sediments are indicated by seismic work (United Geophysical Corporation, 1965). Samples from shotholes A 10 and H 17 from the upper 500 feet show a *Nothofagidites* maximum (Hodgson, *in* United Geophysical Corporation, 1965). *Malvacearumpollis estelae* and *Crassorititriletes vanraadshooveni* were observed additionally, placing this sequence in unit 3. A great abundance of the alga *Pediastrum* is observed in these samples. Parts of the sediments which are known from outcrops and shallow bores are oil shales. The sample from shothole A-10, 580-600 feet, shows *Nothofagidites* less common. Further study is required to show whether this low proportion of *Nothofagidites* is due to a local facies influence or to a stratigraphically deeper position (unit 2).

Plevna area:— An outcrop sample of oil shales from Hazlewood Creek, near Plevna, showed a *Nothofagidites* maximum indicative of unit 3.

Southeast Queensland:— South of Brisbane, one sample from the Mount Tamborine area is recorded by Cookson and Pike (1954), which contains an abundance of *Nothofagidites* (Harris, 1965). Re-interpretation of this occurrence would indicate assignment to unit 3. The sample came from carbonaceous clays under basalt, 300 feet below Curtis Falls, Cedar Creek. The basalts are correlated with the Lamington Group which are of early Miocene age from absolute dating (Webb, Stevens, and McDougall, 1968).

UNIT 4

(Upper parts of early Miocene to late Miocene)

The reference section for unit 4 is the interval from core 2 to core 5 in Aquarius 1. The age evidence is furnished by the recognition of foraminiferal zones N8 to N19 (Palmieri, 1971). Characteristic palynomorphs, not observed in unit 3 are *Chenopodiipollis* sp., *Echitricolporites* sp., *Polyadopollenites* sp., *Polypodiidites usmensis*, and *Polypodiisporites* sp. A further species which is typical for this unit is *Milfordia* sp. In the lower part of this unit the *Nothofagidites* percentage is smaller than in unit 3, decreasing towards the upper part. The first observation of the genus *Polyadopollenites* is in the upper part of this unit within core 3 of Capricorn 1A. *Polypodiisporites* sp. (Pl. 1, Figs. 6, 7, 10) is observed in core 2 of Aquarius 1 for the first time.

Echitricolporites sp. is likely to be in the range of variation of *Echitricolporites spinosus*, a pantropical index fossil for the middle Miocene (Germeraad, Hopping, and Muller, 1968). *Polypodiidites* (al. *Verucatosporites*) *usmensis* is known from tropical Oligocene deposits. *Polyadopollenites* (al. *Acacia*) first thought to be a Pliocene index fossil (Cookson, 1954) is now know from the middle Miocene of southern Australia (Harris, 1971).

In addition to the reference section, this unit can be recognized in cores 2 to 4 in Capricorn 1A.

UNIT 5

(Pliocene)

The reference sample for this unit is from Aquarius 1, core 1, which has been correlated with foraminiferal zone N21 (Palmieri, 1971).

Only one species, *Echitricolporites mcneillyi*, could be recorded as first appearing in this unit. A characteristic feature, however, is the high percentage of pollen of *Echitricolporites* and *Chenopodiipollis*. *Echitricolporites* most likely represents members of the Compositae. Abundance of members of the family Compositae and *Acacia* is typical for the late Miocene-Pliocene, from observations on plant fossils of the southern half of Australia, as mentioned by Brown, Campbell, and Crook (1968, p. 307). *Echitricolporites* ('Compositae pollen' of Couper, (1960)) is known from the Oligocene onwards in New Zealand. In tropical areas the first appearance of *Echitricolporites spinosus* in the middle Miocene is of value in correlations. High percentages of this species are recorded in the Mio-Pliocene of the Carribean area (Germeraad, Hopping, and Muller, 1968, p. 283). The majority of the Compositae are herbaceous plants, generally indicative of open savannah vegetation.

The presence of *Echitricolporites mcneillyi* is suggestive of a correlation with the *Echitricolporites mcneillyi* zone of Germeraad, Hopping, and Muller (1968), representing the tropical Pliocene.

In addition to the reference sample, this unit could only be recognised in Capricorn 1A, core 1.

COMPARISON OF THE QUEENSLAND UNITS WITH PALYNOLOGICAL ZONATIONS IN AUSTRALIA AND OVERSEAS.

Southern Australia:— Harris (1971) proposed a zonation of the Paleocene-Pliocene interval in southern Australia. Four tentative 'zonules' cover the late Oligocene-Pliocene interval. Only one of the species listed, *Polyadopollenites* sp. (al. *Acacia*), has similar importance in Queensland. However, the range is not directly comparable, as '*Acacia*' appears first in foraminiferal zone N 8 in the St. Vincent Basin, slightly later in the Otway Basin (Harris, pers. comm.) and in zone N 14 (core 3) in Capricorn 1A. The later appearance in Queensland, however, may be due to the relative rarity of these forms and lack of enough sampling points. (Only four samples were studied in the interval between N8 and N14). In Aquarius 1, *Polyadopollenites* sp. has been found in core 1 only.

New Zealand:— No formal zonation was given by Couper (1960). The Oligocene-Pliocene interval is divided into four floral sequences. The change of predominance of the *brassi* and the *fusca* groups of *Nothofagidites* was interpreted as related to the change from warmer to temperate climates. The peak of the *Nothofagidites brassi* group in the early Miocene in Queensland coincides with a maximum of this group in New Zealand. No major occurrences of the *fusca* group are observed however throughout the whole Queensland sequence. No biostratigraphic correlations except very general ones could be made directly with the New Zealand palynomorph sequences, although many of the species seem to be morphologically similar to or identical with Australian species. Several species similar to those of Couper (1960), like *Retistephanocolpites* (al. *Polycolpites*) *reticulatus*, *Milfordia* sp. (al. Restoniaceae), *Polypodiidites usmensis* (=?*P. perverrucatus*), and *Echitricolporites* group (al. Composite), show minor differences in their stratigraphic distribution. The Paleocene maximum age of unit 1 is supported by Couper's observations of the first appearance of '*Triorites*' *harrisii*, *Myrtaceidites* spp., and *Cupanieidites* spp.

Pantropical zones:— The pantropical zones of Germeraad, Hopping, and Muller (1968) seem to be applicable for the Queensland Miocene-Pliocene interval. *Crassoretitriletis vanraadshooveni* seems to have appeared in Queensland close to the base of the Miocene, after its first occurrence in Nigeria (late Oligocene), and before its first appearance in Borneo (higher part of early Miocene). The Pliocene history of Queensland microfloras seems to be similar to that of the Miocene-Pliocene of the Carribean area, where considerable quantities of *Echitricolporites* (*Asteraceae*) pollen are found together with *E. mcneillyi* (the index species for the Pliocene).

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APPENDIX

List of samples not recorded in text-figures.

Abbreviations:— r: 1-3%
c: 3-10%
a: more than 10%

G.S.Q. Narrows N1,300 ft.—grey-green shale. For location see Ball (1946).

r Bisaccate pollen grains
r *Cupanieidites orthotheichus*
c *Cyathidites minor*
r *Malvacipollis diversus*
r *Nothofagidites hetera*
r *N. mataurensis*
r *N.* cf. *suggatei*
r *N.* sp. aff. *N. waipawaensis*
r *Parsonsidites* sp.
r *Restoniidites homeopunctatus*
r *Rouseisporites* sp.
a *'Triorites' harrisii*
c *'T' orbiculatus*

G.S.Q. Narrows N8, 180 ft.—laminated dark grey shale.

r Bisaccate pollen grains
c *Cupanieidites orthotheichus*
c *Ilexpollenites* sp.
r *Liliacidites* sp.
c *Malvacipollis diversus*
r *Parsonsidites* sp.
c *Polypodiaceoisporites* sp. aff. *P. retirugatus*
r *Proteacidites pachypolus*
r *P. parvus*
r *P. subscabratus*
r *P.* sp. 1
r *Restoniidites homeopunctatus*
r *Schizosporis* sp.
r *Striatricolporites minor*
r *Tricolpites asperamarginis*
r *Tricolpites* cf. *fissilis*
a *'Triorites' harrisii*
a *'T' orbiculatus*

G.S.Q. Narrows N8, 300 ft.—dark spotted grey-brown mudstone.

c *Araucariacites australis*
c Bisaccate pollen grains.
c *Cupanieidites orthotheichus*
r *Cyathidites minor*
r *Dilwynites tuberculatus*
c *Ilexpollenites* sp.
c *Liliacidites* sp.
r *Myrtaceidites eucalyptoides*
r *Nothofagidites* sp. 1
r *Osmundacidites* sp.
c *Polypodiaceoisporites* sp. aff. *P. retirugatus*
r *Proteacidites* sp. aff. *P. granulatus*
a *'Triorites' harrisii*
c *'T' orbiculatus*

G.S.Q. Narrows N9, 296 ft.—medium grey-brown silty shale.

c Bisaccate pollen grains.
c *Cupanieidites orthotheichus*
r *'Cranwellia' striata*
r *Cyathidites australis*
r *C. major*
r *Dictyophyllidites* sp.
r *Dilwynites granulatus*
r *Ilexpollenites* sp.
r *Gleicheniidites circinidites*
r *Laevigatosporites ovatus*
r *Liliacidites* sp.
c *Malvacipollis diversus*
r *Myrtaceidites eugeniioides*
r *M. parvus*
r *Nothofagidites* cf. *mataurensis*
r *N.* sp. aff. *N. waipawaensis*
r *Parsonsidites* sp.
r *Proteacidites crassipora*
r *P. cyrensis*
r *P. pachypolus*
r *P.* cf. *subcabratus*
c *Restoniidites homeopunctatus*
r *Santaluminidites* cf. *cainozoicus*
r *Striatricolporites minor*
r *Tricolpites asperamarginis*
r *Tricolpites* sp. aff. *T. thomasii*
a *'Triorites' harrisii*
c *'Triorites' orbiculatus*

A.F.O. Mackenzie seismic shothole H 17, 180-195 ft. For location see United Geophysical Corporation (1965)—grey shale

r *Araucariacites australis*
c Bisaccate pollen grains
a *Botryococcus* sp.
c *Casuarinidites cainozoicus*
r *Cupanieidites orthotheichus*
r *Cyathidites australis*
r *Dacrydiumites florinii*
r *Laevigatosporites ovatus*
r *Liliacidites* sp.
c *Malvacipollis diversus*
r *Monoporites* sp.
r Myrtaceidites *parvus*
r *Nothofagidites* sp. 2
c *N.* sp. 3
r *N. falcata* (asymetric form)
c *N. hetera*
a *N. mataurensis*
r *Osmundacidites* sp.
r *Proteacidites* sp.
c *Striatricolporites minor*
r *'Tricolporites' microreticulatus*
c *'Triorites' orbiculatus*

A.F.O. Mackenzie seismic shothole A 10, 465-480 ft.—grey shale.

c *Cupanieidites orthotheichus*
c *Cyathidites* sp.
r *Crassoretitriletes vanraadshooveni*
r *Dilwynites granulatus*
a *Laevigatosporites* spp.
r *Malvacearumpollis estelae*
r *Nothofagidites aspera*
c *N. sp.*
r *Polypodiaceoisporites* sp. aff. *P. retirugatus*
r *Proteacidites pachypolus*
c *P.* sp.
r *Restoniidites homeopunctatus*
c *Rouseisporites* sp.
a *'Triorites' harrisii*
a *'T'. orbiculatus*

Cape Hillsborough surface samples; intertidal outcrops at Donna Bay (N-coast), collected by V. Palmieri.—grey-brown shale.

c *Araucariacites australis*
a Bisaccate pollen grains
r *Dilwynites tuberculatus*
r *Laevigatosporites ovatus*
r *Malvacipollis diversus*
r *Myrtaceidites eugeniioides*
c *Nothofagidites* sp.
r *Parsonsidites* sp.
c *Tricolporites* sp.
c *'Triorites' harrisii*
c *'T'. orbiculatus*

Plevna area, Hazlewood Creek; surface sample of oil shale outcrop underlying basalts (for exact location see Reid (1942), collected by C. Swarbrick).—brown oil shale.

c Bisaccate pollen grains
r *Laevigatosporites major*
r *Malvacipollis diversus*
r *Myrtaceidites parvus*
r *Nothofagidites* sp. aff. *N. brachyspinulosa*
c *N.* sp. aff. *N. falcata*
c *N. hetera*
a *N. mataurensis*
r *Proteacidites granulatus*
r *P. pachypolus*
r *P.* sp.
r *Santaluminidites cainozoicus*
r '*Tricolpites*' *thomasii*
r '*Tricolporites*' sp.
r '*Triorites*' *orbiculatus*

Waterpark Creek area; surface samples from coal seam, in Tomahawk Creek, 100 yards east of junction with Valentine Creek—lignite.

c *Anacolosidites* sp.
c Bisaccate pollen grains
r *Cupanieidites orthotheichus*
c *Laevigatosporites major*
r *Liliacidites* sp.
r *Malvacipollis diversus*
c *Myrtaceidites eucalyptoides*
a *M. mesonesus*
c *Nothofagidites hetera*
c *N. mataurensis*
r *Proteacidites subscabratus*
c *Retitricolporites byfieldensis*
r *Santaluminidites* cf. *cainozoicus*
r *Tricolpites thomasii*
r '*Tricolporites*' sp. 1

G.S.Q. Waterpark Creek N1, 274 ft., for location see Shepherd (1951)—light to medium grey coaly shale.

r Bisaccate pollen grains
r *Camarozonosporites* sp.
r *Cupanieidites orthotheichus*
r *Laevigatosporites* sp.
c *Malvacipollis diversus*
c *Myrtaceidites mesonesus*
a *Nothofagidites mataurensis*
c *N.* spp.
r *Polypodiidites* sp. aff. *P. minimus*
r *Proteacidites pachypolus*
r *P. subscabratus*
r *Tricolpites thomasii*
a '*Triorites*' *harrisii*

G.S.Q. Waterpark Creek N2, 195 ft.—light grey mudstone.

r *Anacolosidites* sp.
r *Beaupreaidites* sp.
r Bisaccate pollen grains
r *Crassoretitriletes* cf. *vanraadshooveni*
r *Corsinipollenites* sp. aff. *C. champlainensis*
r *Ilexpollenites* sp.
c *Laevigatosporites* sp.
a *Myrtaceidites* sp.
r *Nothofagidites mataurensis*
r *Osmundacidites* sp.
r *Proteacidites parvus*
r *Psilatricolporites* sp.
c *Retitricolporites* sp.
r *Santaluminidites cainozoicus*
r *Schizosporis* sp.
r *Todisporites* sp.
r '*Tricolporites*' sp. 1
c Trilete spores

G.S.Q. Waterpark Creek N2, 102-109 ft.—medium grey, coaly mudstone.

c *Anacolosidites* sp.
r *Beaupreaidites* sp.
c Bisaccate pollen grains
r '*Cranwellia*' sp.
c *Cyathidites* sp.
r *Ilexpollenites* sp.
c *Laevigatosporites* sp.
r *Malvacipollis diversus*
a *Myrtaceidites eucalyptoides*
a *M. parvus*
r *Osmundacidites* sp.
r *Proteacidites* sp. aff. *P. granulatus*
r *P. minimus*
r *Retitricolpites* sp.
r *Santaluminidites cainozoicus*
c *Tricolpites thomasii*

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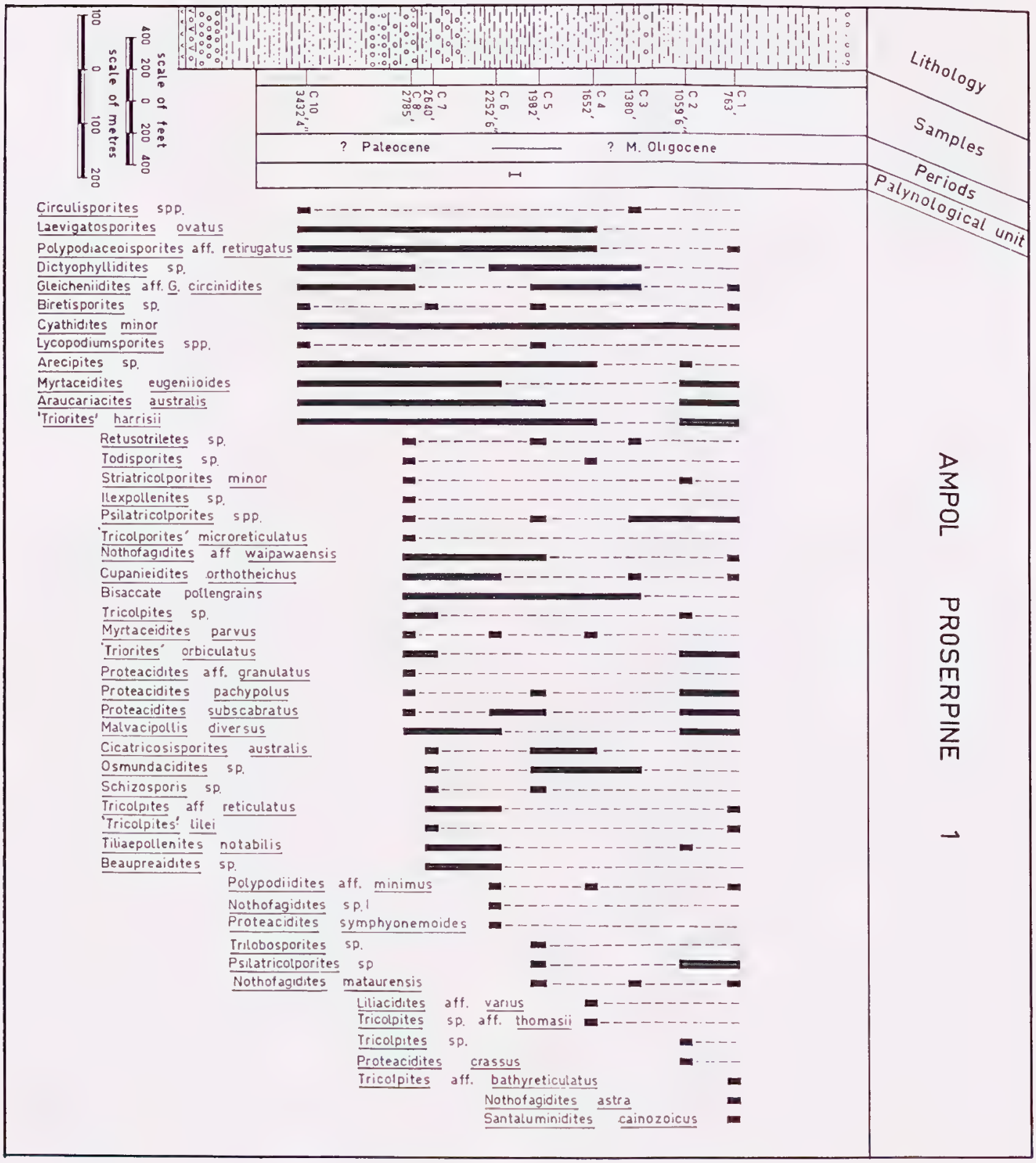


Figure 4 —Distribution of species in Ampol Proserpine 1.

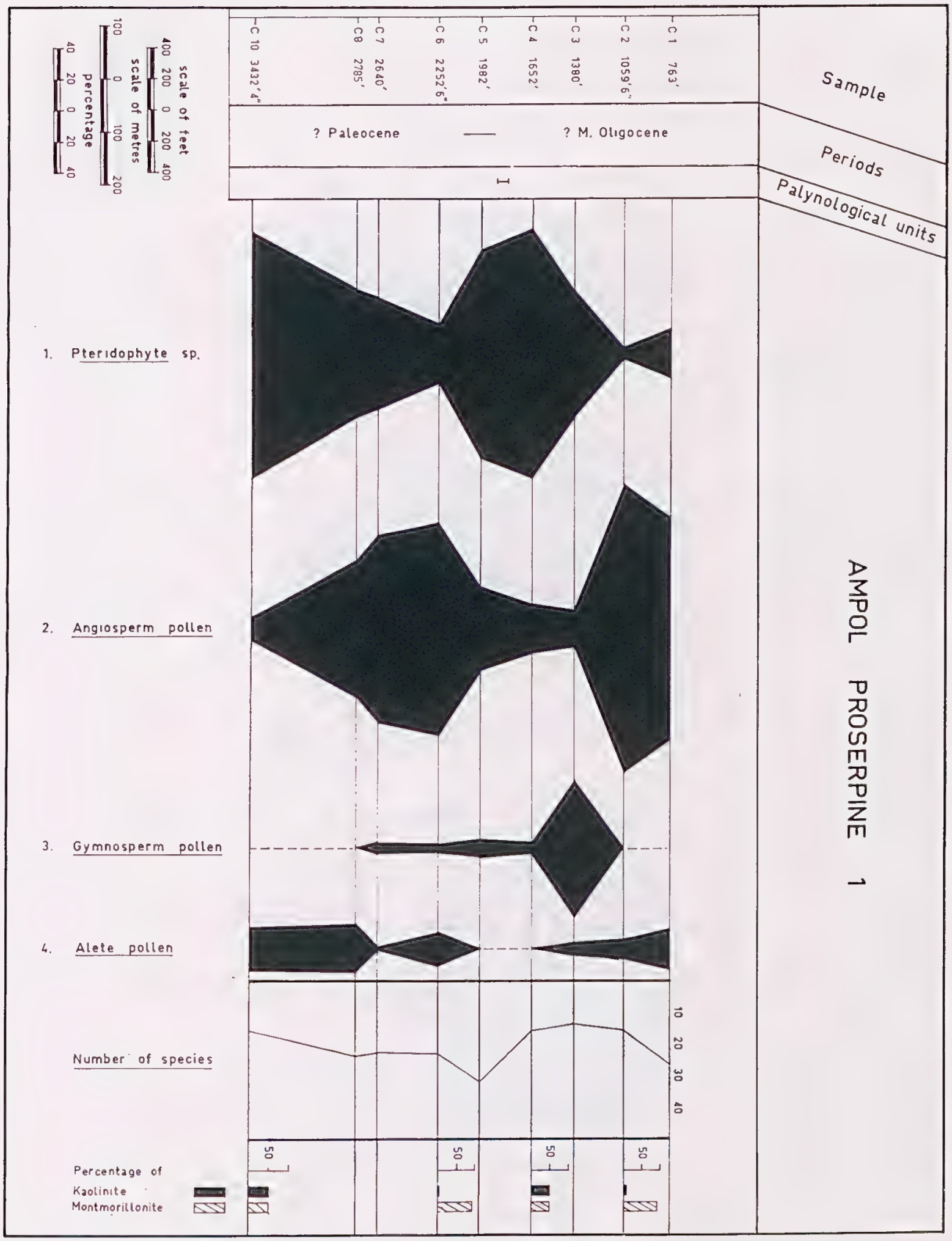


Figure 5 —Distribution of major groups in Ampol Proserpine 1. For lithology see Figure 2. Two major changes of alternative predominance of angiosperm pollen and pteridophyte spores are observed. High species numbers are typical for periods between maxima. In the case of angiosperm maxima, the clay minerals show montmorillonite predominance, while kaolinite equals montmorillonite during pteridophyte maxima.

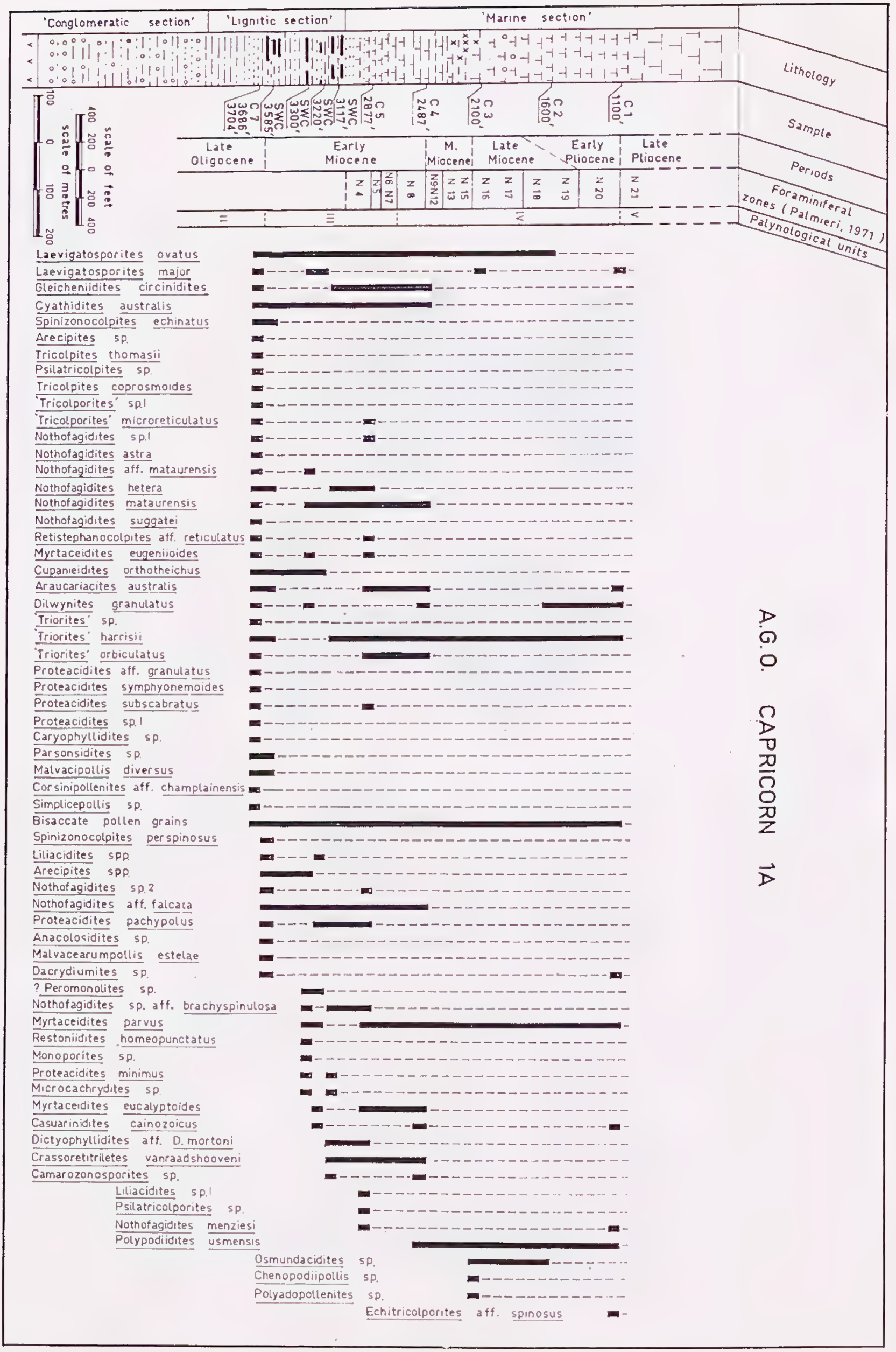


Figure 6 —Distribution of species in A.G.O. Capricorn 1A.

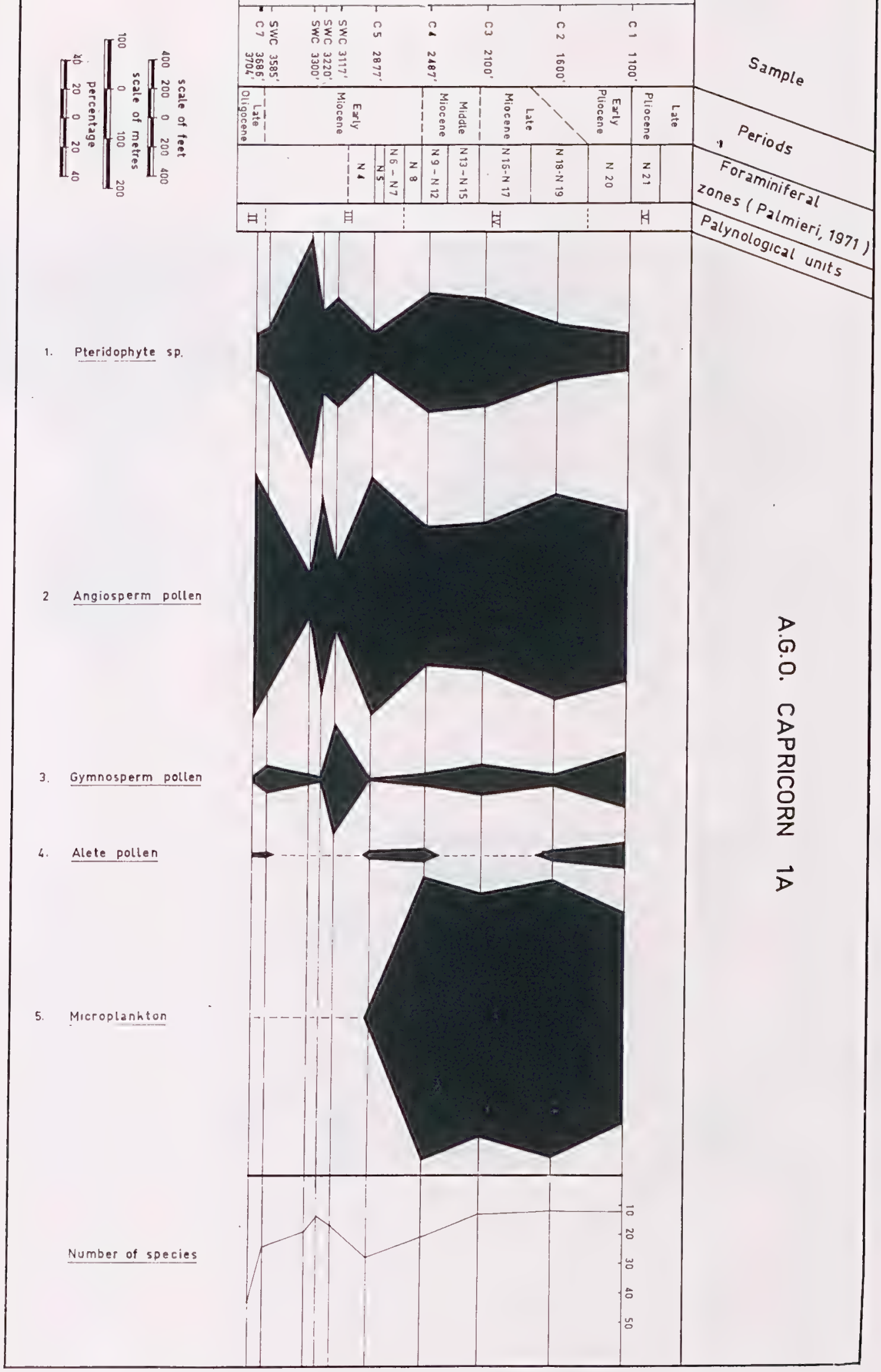


Figure 7.—Distribution of major groups in A.G.O. Capricorn 1A. For lithology see Figure 6. The rapid change of maxima over short distances in the lower part of the section corresponds with the 'lignitic section' and seems to be typical for the deposition of sporomorphs close to their environment. In the marine environment only slight changes take place. The number of species increases during facies changes. Microplankton percentage shown in relation to total sporomorph numbers.

A.G.O. AQUARIUS 1

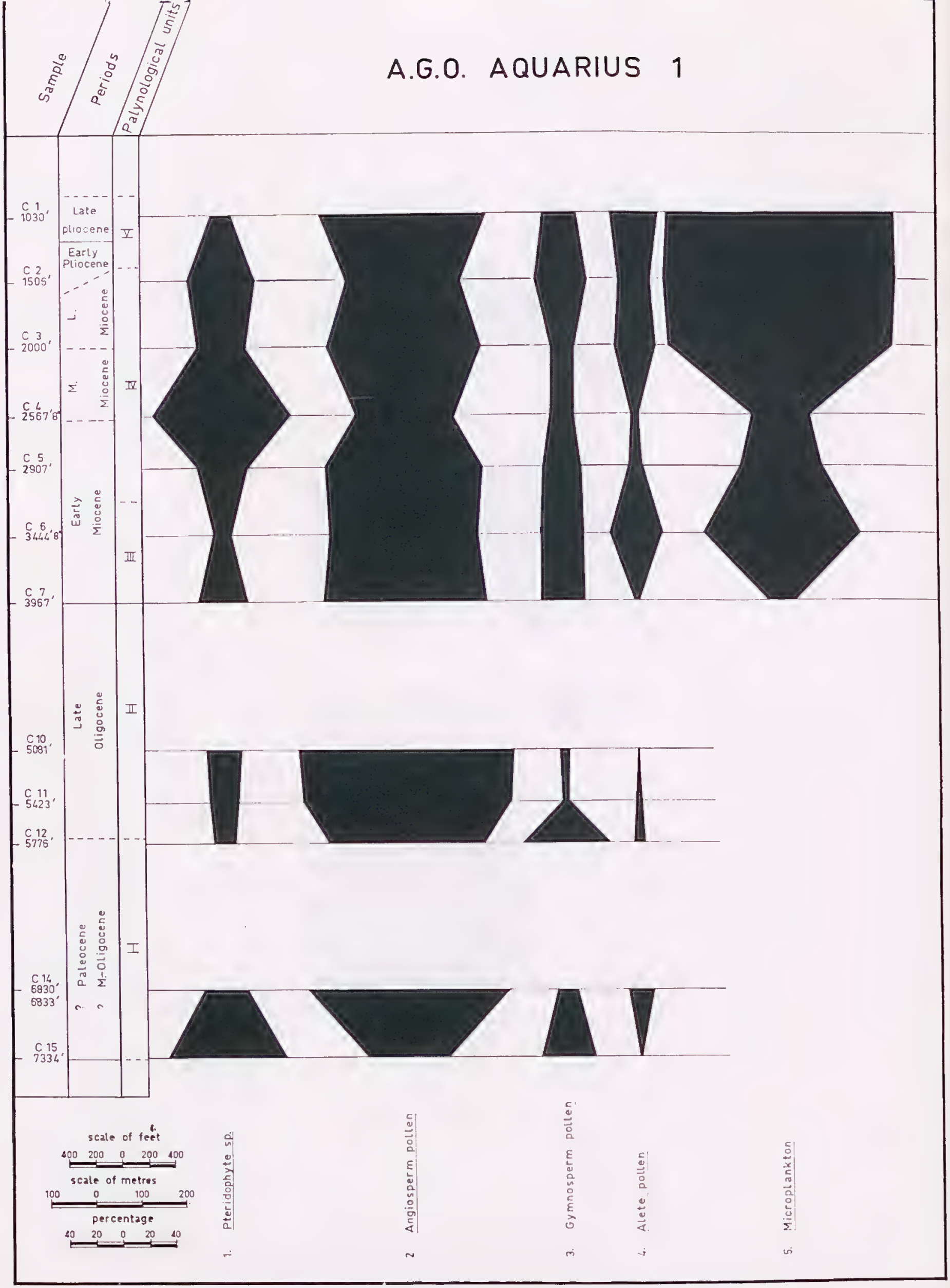


Figure 8 —Distribution of major groups in A.G.O. Aquarius 1. For lithology and species distribution see Figure 9. Microplankton percentage shown in relation to total sporomorph numbers.

PLATE 1

(All photographs approximately ×1000)

Figure 1 —*Polypodiidites minimus* Couper, 1960 (equatorial focus) (p. 6)

Figures 2, 3 and 4 —?*Peromonolites* sp. (surface focus) (p. 6)

Figure 5 —*Laevigatosporites major* (Cookson) Krutzsch, 1959 (equatorial focus) (p. 5)

Figures 6, 7 and 10 —*Polypodiisporites* sp. (p. 5)

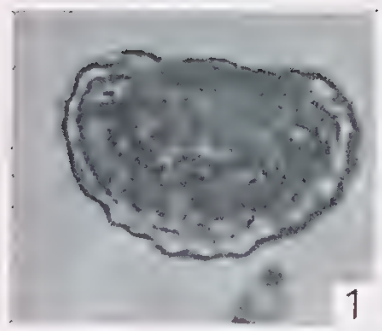
Figures 8 and 9 —*Polypodiidites usmensis* (van der Hammen) comb. nov. (p. 6)

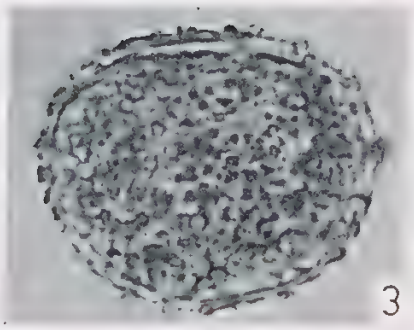
Figures 11 and 15 —*Podocarpidites* spp. (p. 7)

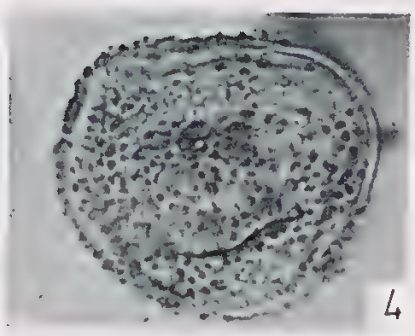
Figure 12—*Dacrydiumites* sp. (p. 6)

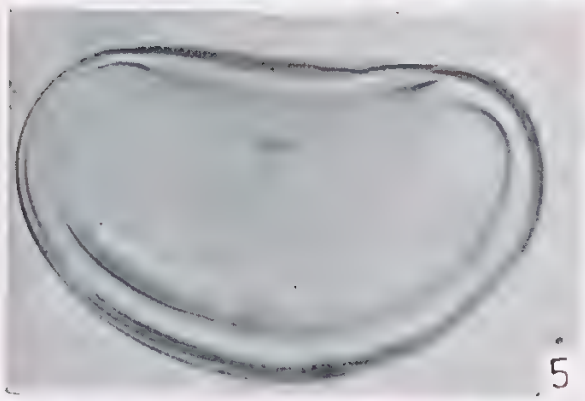
Figures 13 and 14 —*Circulisporites* spp. (p. 19)

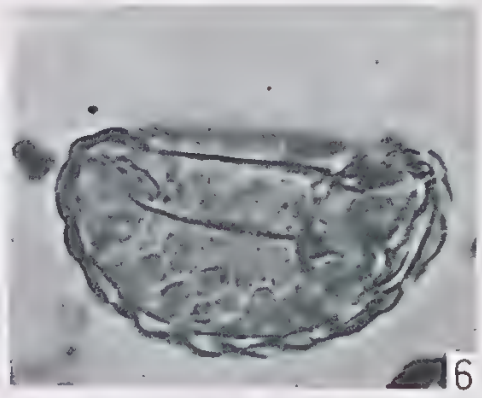
Figure 16—*Dilwynites granulatus* Harris, 1965 (p. 7)

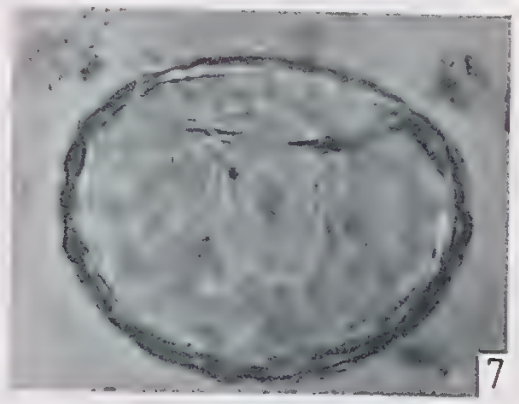


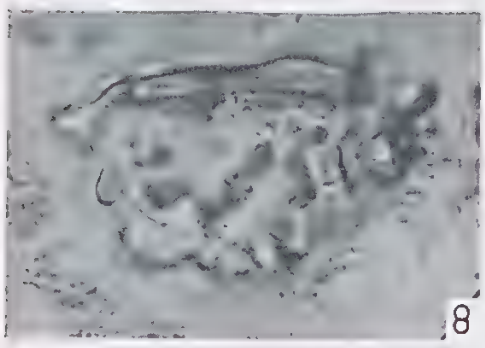


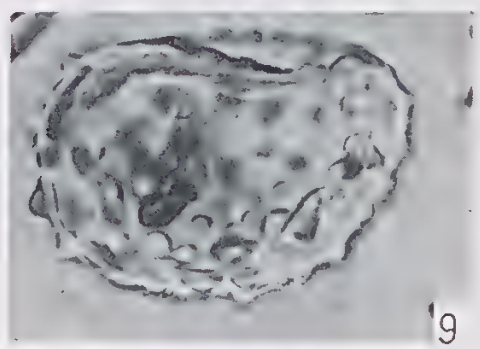


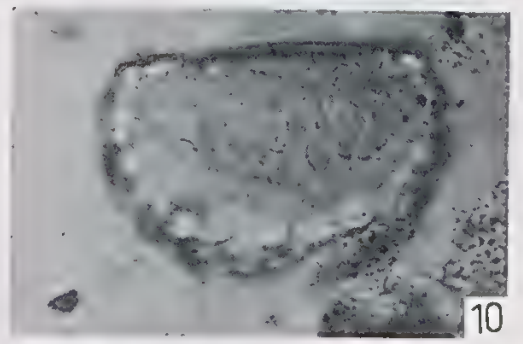


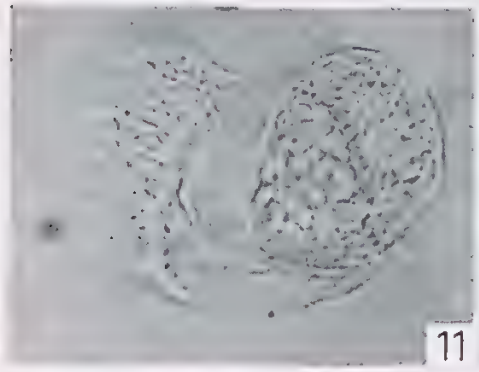


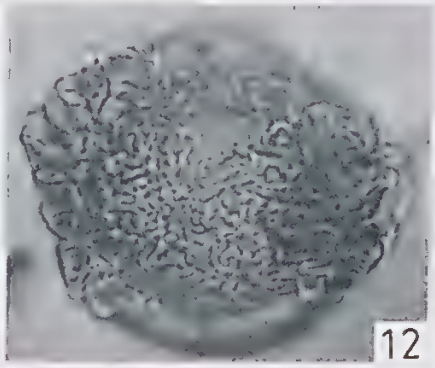


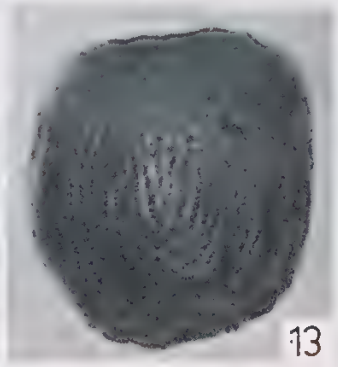


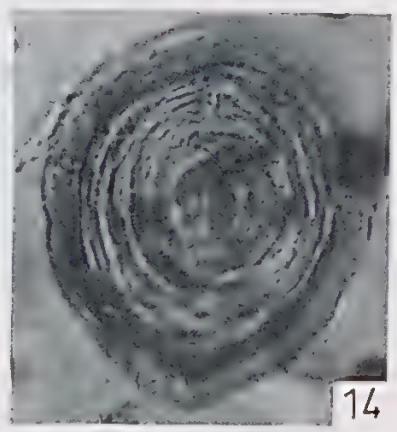


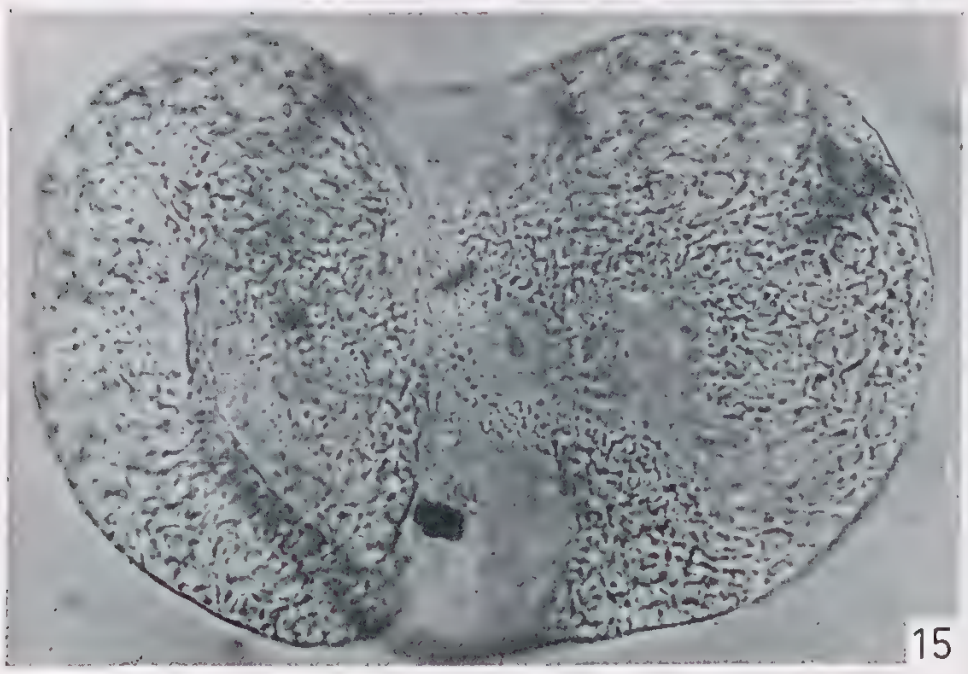












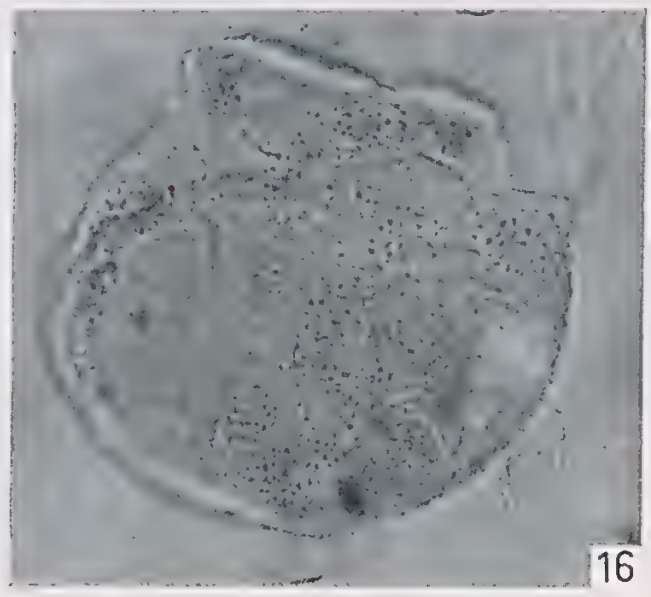


PLATE 1

PLATE 2

(All photographs approximately ×1000)

Figure 1 —*Gleicheniidites circinidites* (Cookson) Dettmann, 1963 (p. 5)

Figures 2 and 3 —*Polypodiaceoisporites* sp. aff. *P. retirugatus* Muller, 1968 (p. 5)

Figure 4 —*Cyathidites minor* Couper, 1953 (p. 3)

Figure 5 —*Gleicheniidites* sp. aff. *G. circinidites* (Cookson) Dettmann, 1963 (p. 5)

Figures 6 and 7 —*Dictyophyllidites* sp. aff. *D. mortoni* (de Jersey) Playford & Dettmann, 1965 (p. 4)

Figure 8 —*Dictyophyllidites* sp. aff. *D. harrisii* Couper, 1958 (p. 3)

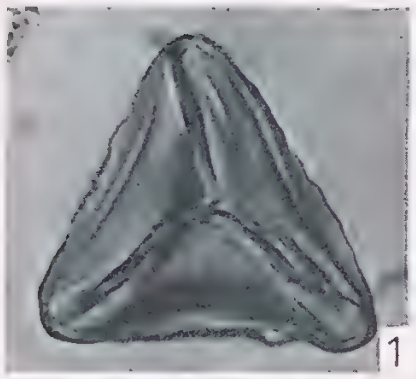
Figures 9 and 12 —*Crassoretitriletes vanraadshooveni* Germeraad, Hopping & Muller, 1968 (p. 4)

Figure 10—*Osmundacidites* sp. (p. 4)

Figure 11—*Lycopodiumsporites* sp. (p. 4)

Figure 13—*Rouseisporites* sp. (p. 4)

Figures 14 and 15 —*Camarozonosporites* sp. (p. 5)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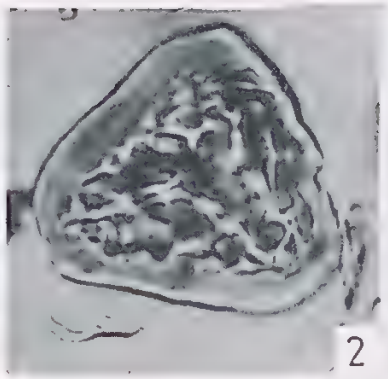
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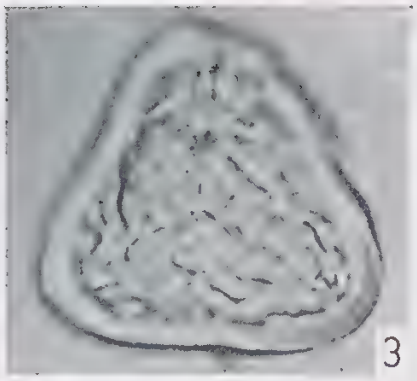
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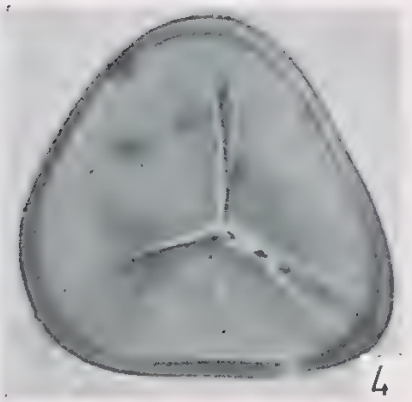
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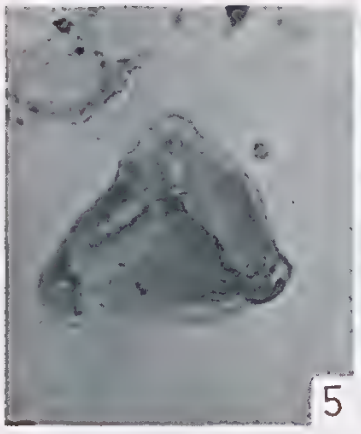
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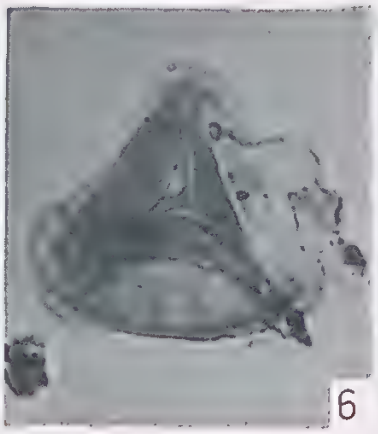
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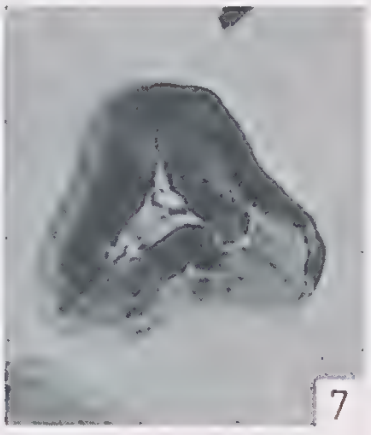
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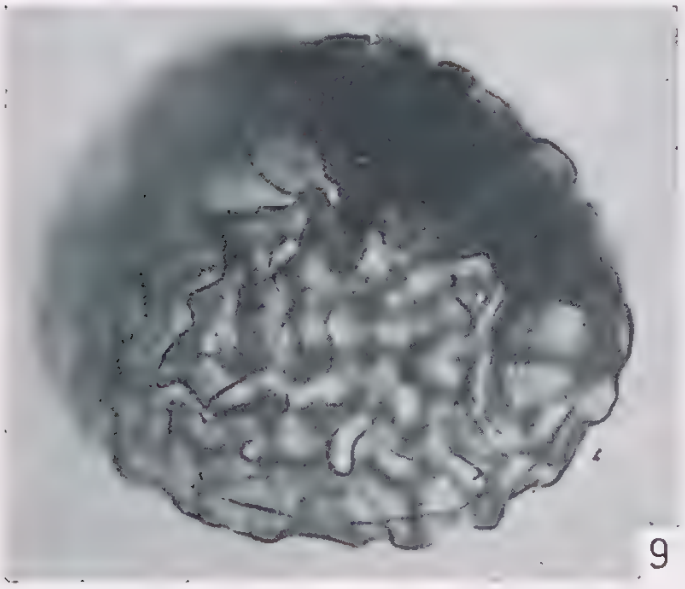
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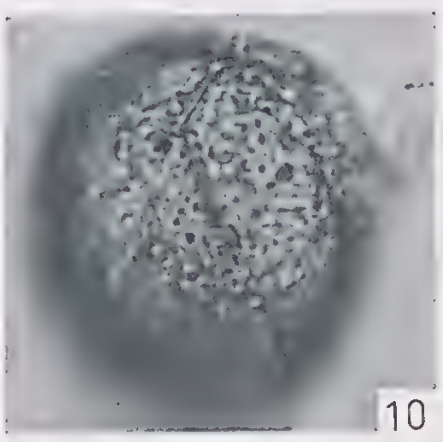
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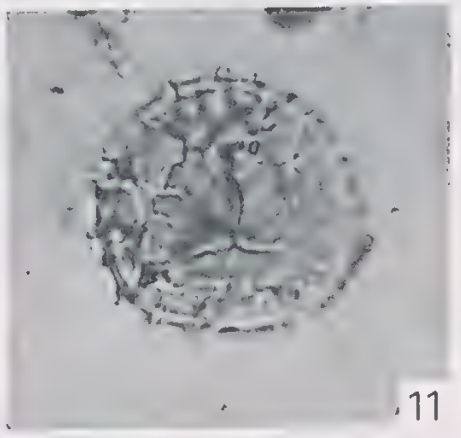
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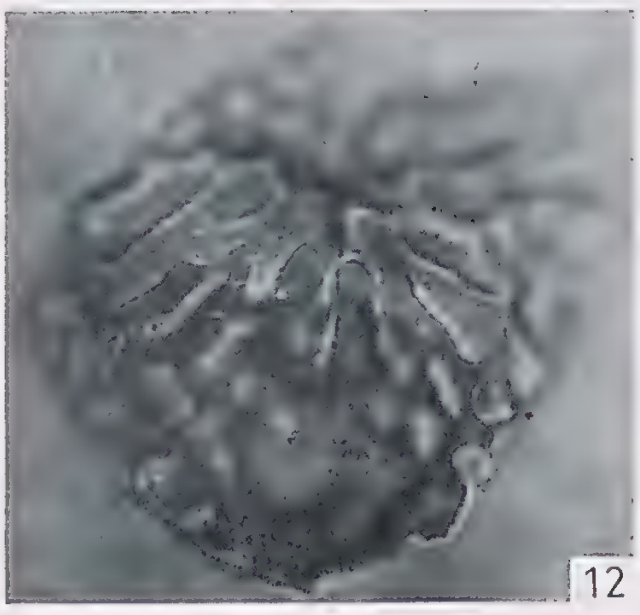
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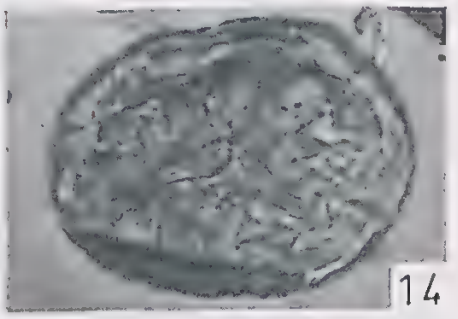
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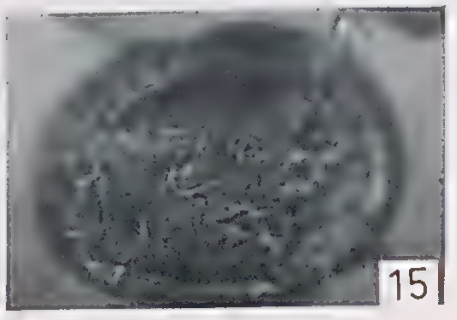
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PLATE 2

PLATE 3

(All photographs approximately ×1000)

Figure 1 —?*Striatricolporites* sp. (p. 13)

Figures 2 to 4 —*Striatricolporites minor* Muller, 1968 (p. 13)

Figure 5 —*Psilatricolpites* sp.(p. 13)

Figure 6 —*Ilexpollenites* sp. (p. 12)

Figures 7 and 8 —'*Tricolporites*' *microreticulatus* Harris, 1965 (p. 12)

Figures 9, 10 and 15 —*Zonocostites ramonae* Germeraad, Hopping & Muller, 1968 (p.13)

Figure 11—*Arecipites* sp. (p. 7)

Figure 12—*Retitricolporites byfieldensis* sp. nov. (Holotype) (p. 12)

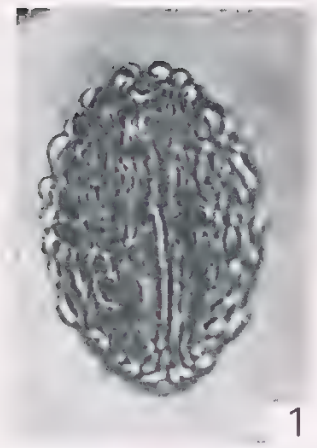
Figure 13 and 14 —*Retitricolporites byfieldensis* sp. nov. (p. 12)

Figures 16 to 19 —*Liliacidites* spp. (18 proximal, 19-distal focus of same specimen) (p.7)

Figures 20 and 21 —*Spinizonocolpites echinatus* Muller, 1968 (p. 7)

Figure 22—*Spinizonocolpites perspinosus* (Couper) comb. nov. (p. 7)

Figure 23—*Gemmamonocolpites* sp. (p. 7)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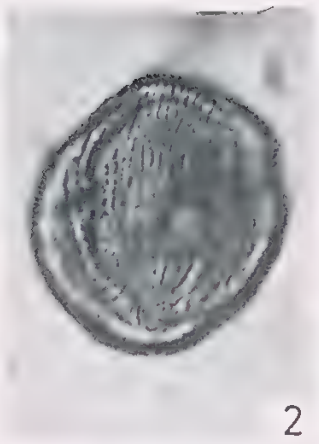
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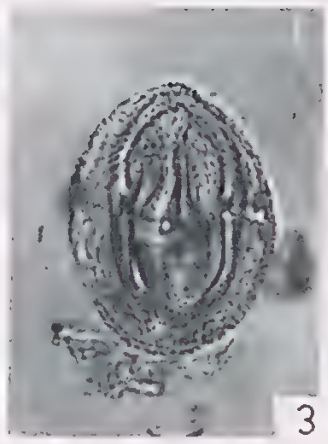
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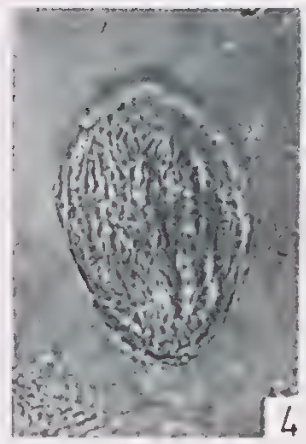
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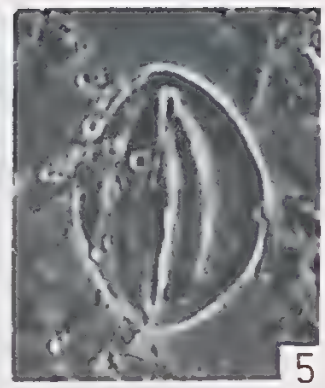
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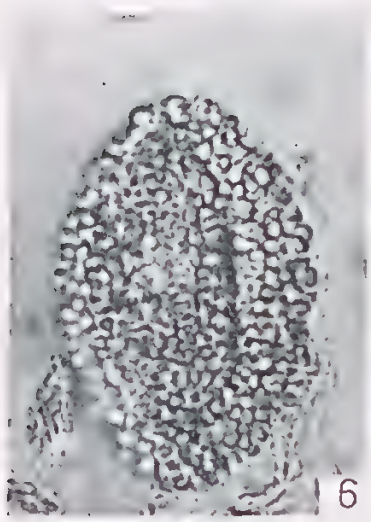
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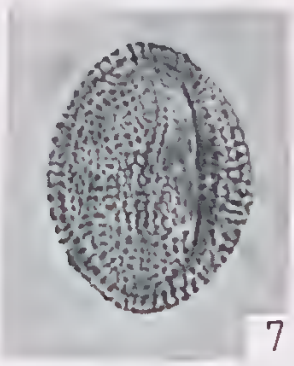
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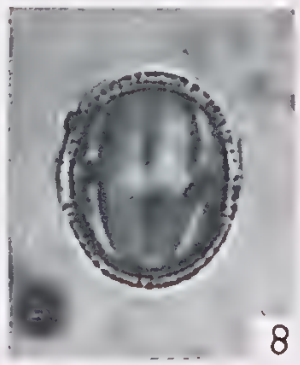
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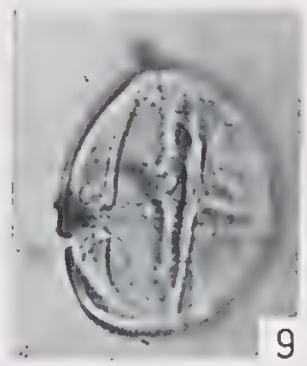
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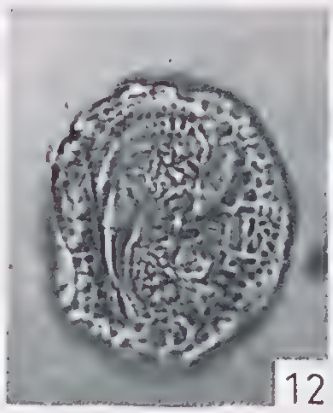
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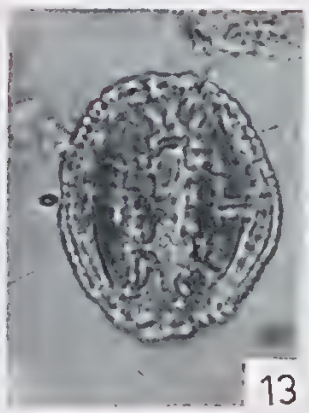
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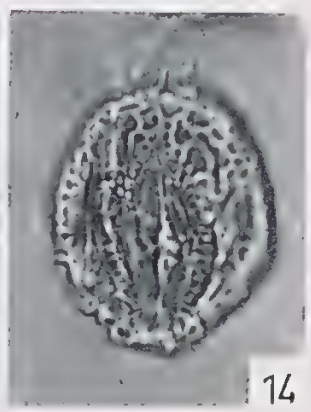
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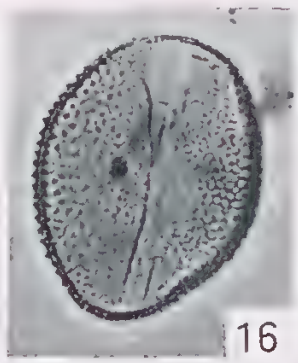
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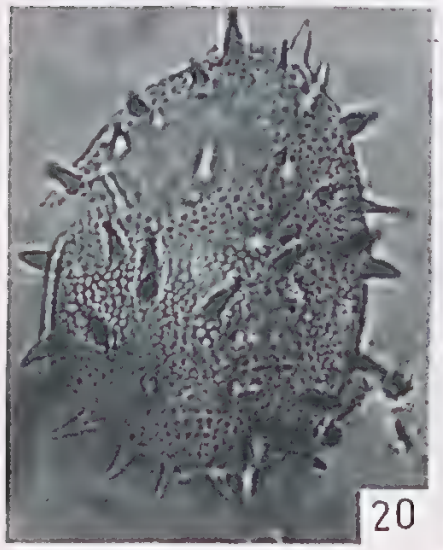
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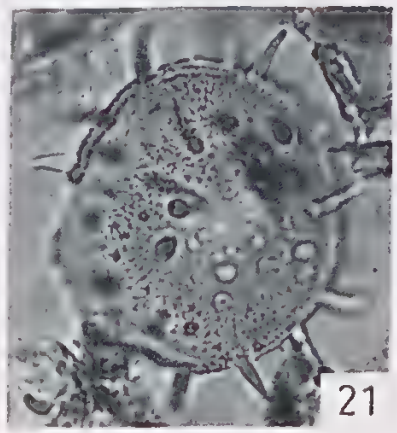
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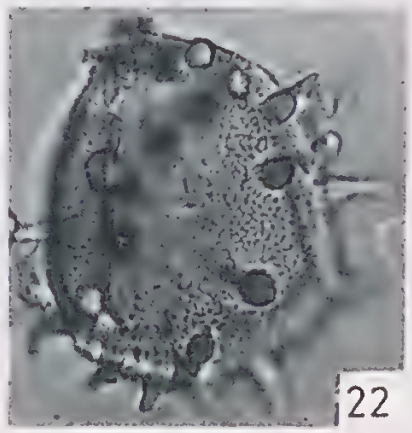
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PLATE 3

PLATE 4

(All photographs approximately ×1000)

Figure 1 —*Echitricolporites mcneillyi* Germeraad, Hopping & Muller, 1968 (p. 14)

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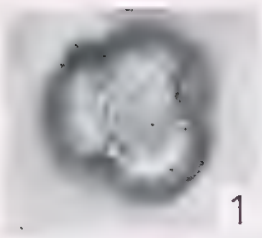
Figure 28—'*Tricolpites*' *lilliei* Couper, 1953 (p. 9)

Figure 29—'*Tricolporites*' sp. 1 (p. 12)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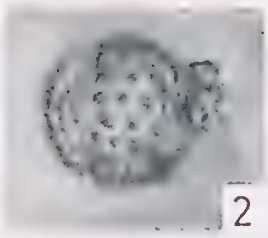
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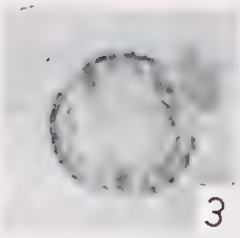
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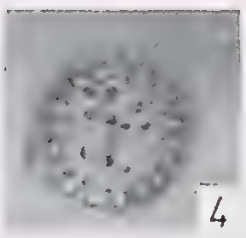
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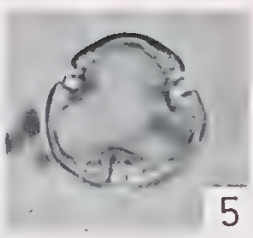
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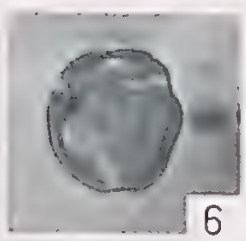
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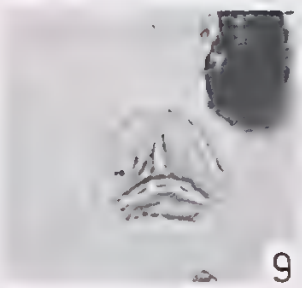
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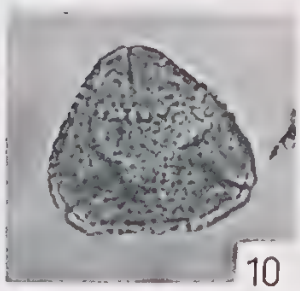
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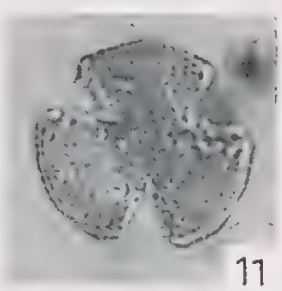
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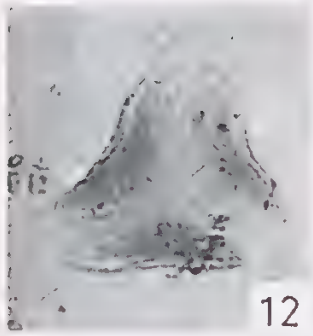
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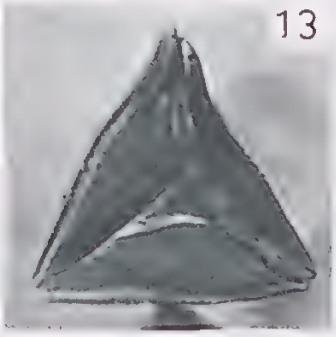
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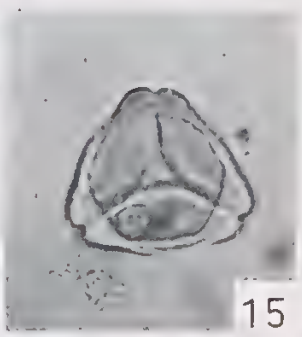
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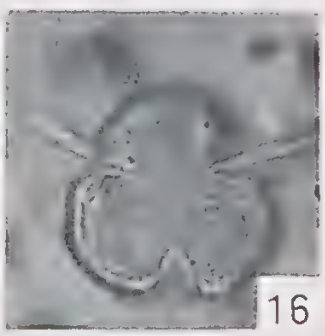
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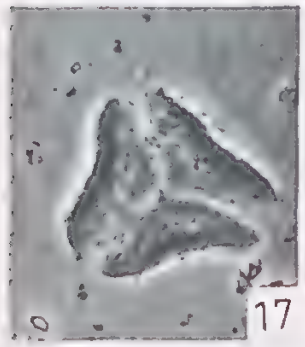
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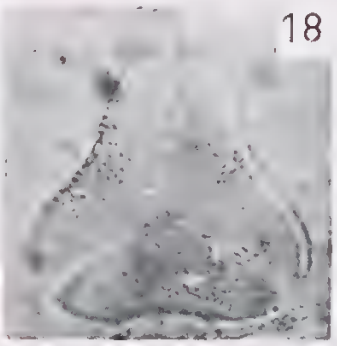
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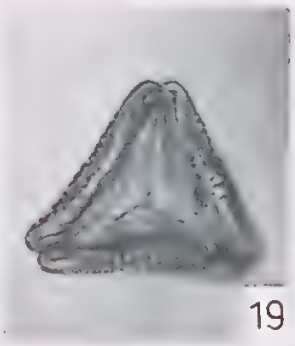
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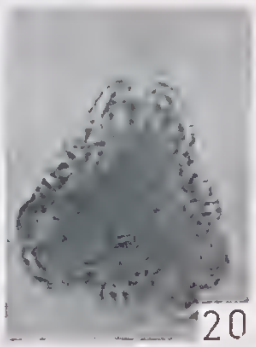
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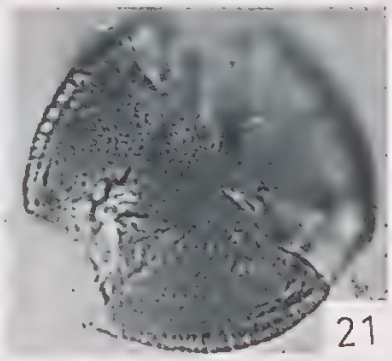
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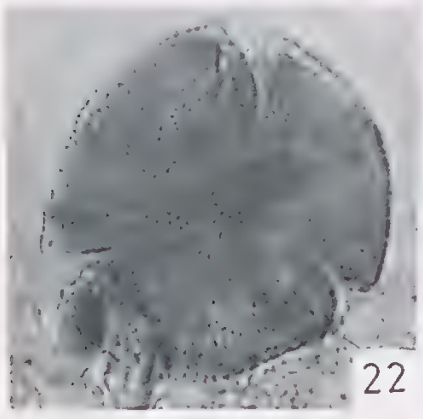
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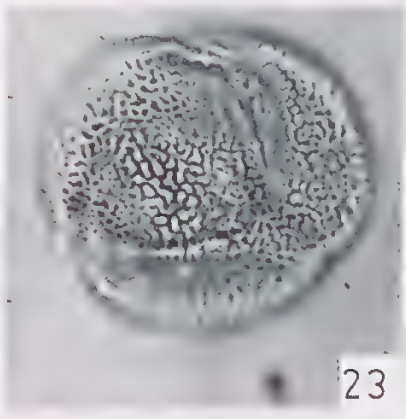
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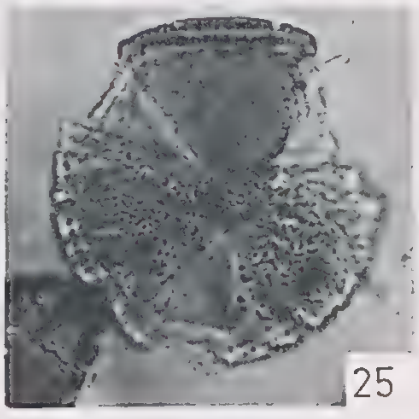
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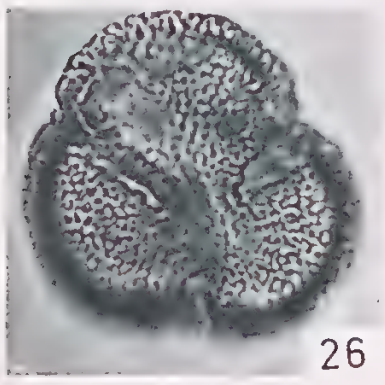
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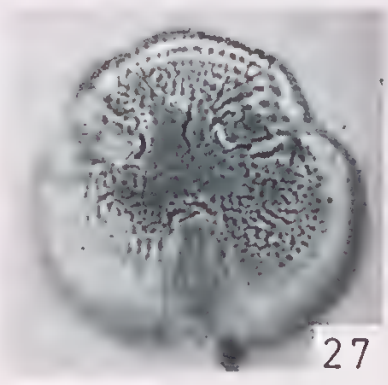
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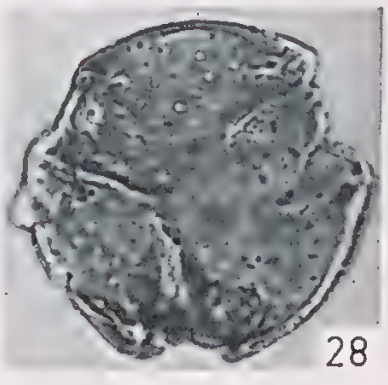
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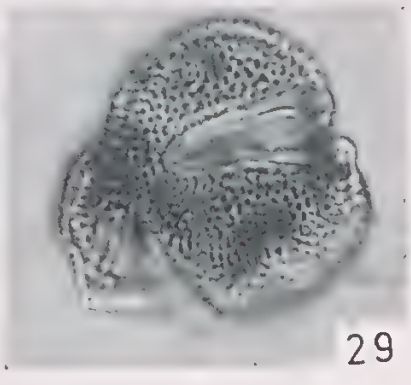
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PLATE 4

PLATE 5

(All photographs approximately ×1000)

Figures 1 to 4 —*Anacolosidites* sp. (p. 17)

Figure 5 —*Casuarinidites cainozoicus* Cookson & Pike, 1954 (p. 17)

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Figure 7 —*'Triorites' harrisii* Couper, 1953 (p. 17)

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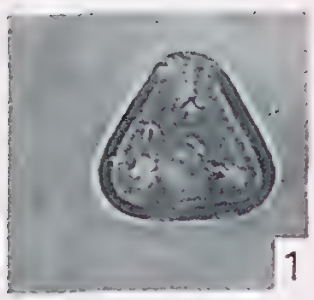
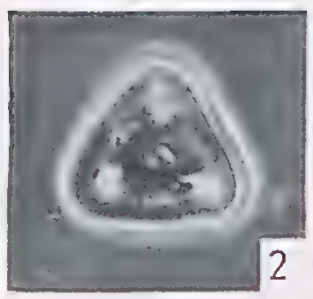
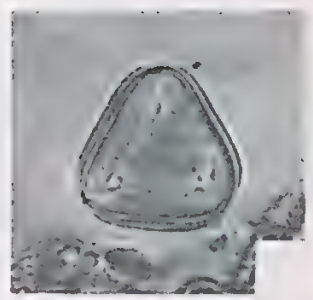
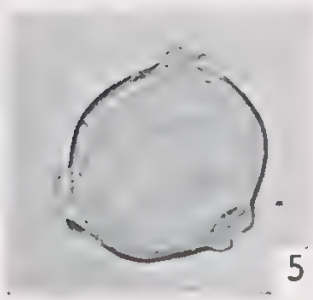
Figure 17—*Proteacidites* sp. aff. *P. granulatus* Cookson, 1953 (p. 16)

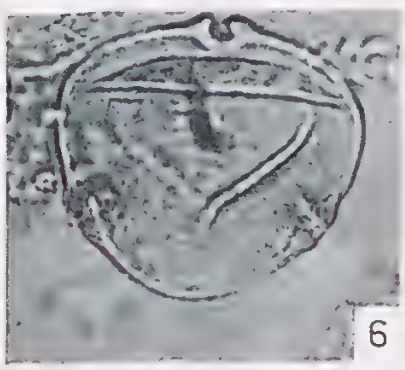
Figure 18—*Proteacidites* sp. aff. *P. annularis* Cookson, 1950 (p. 16)

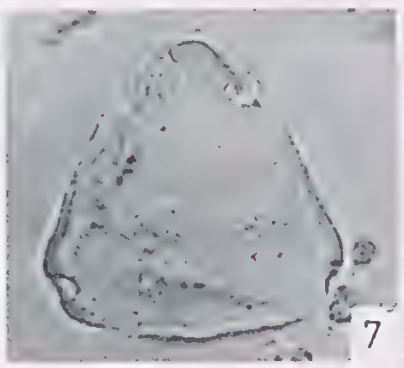


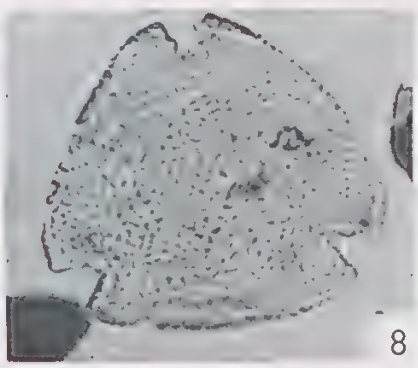


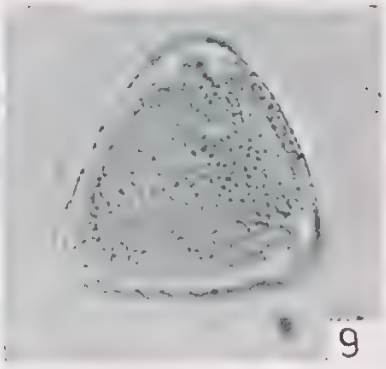


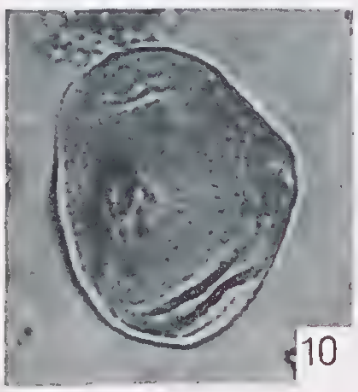


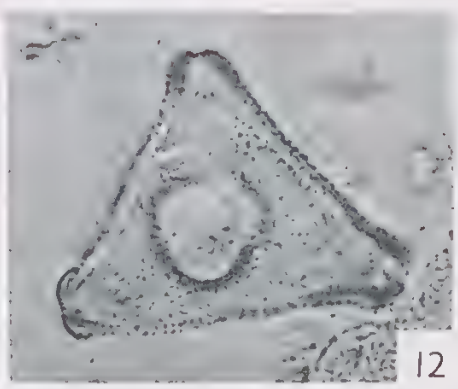


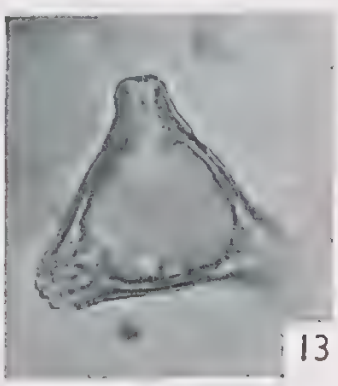


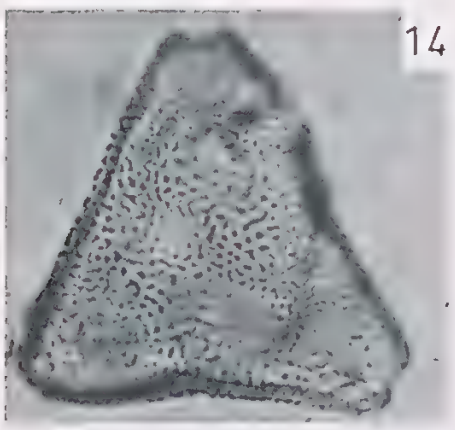


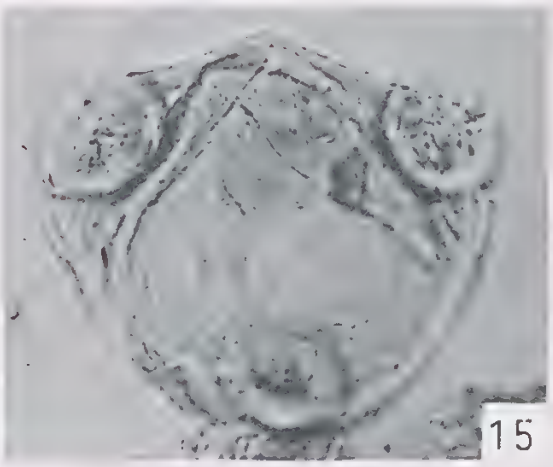


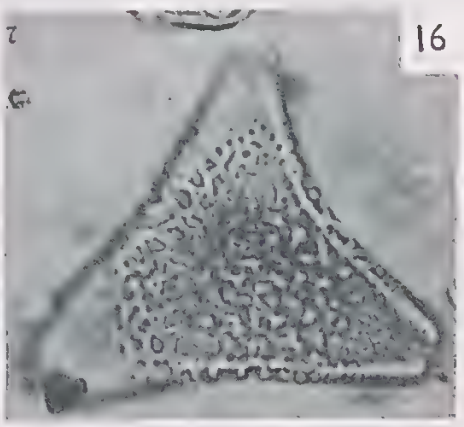


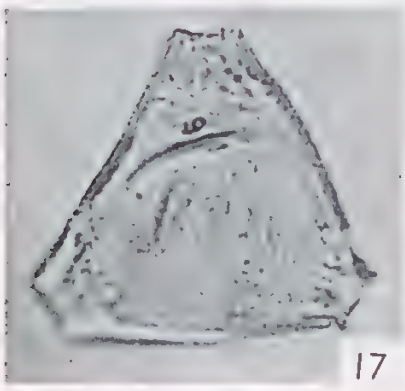


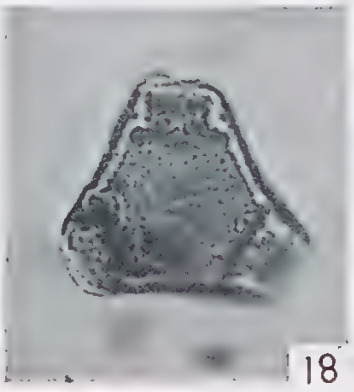


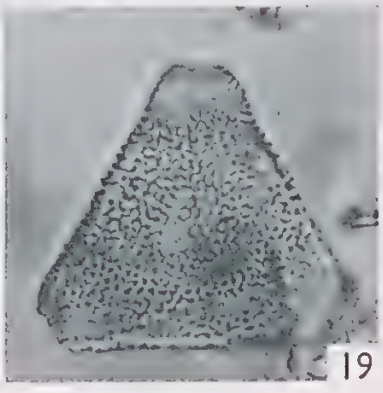












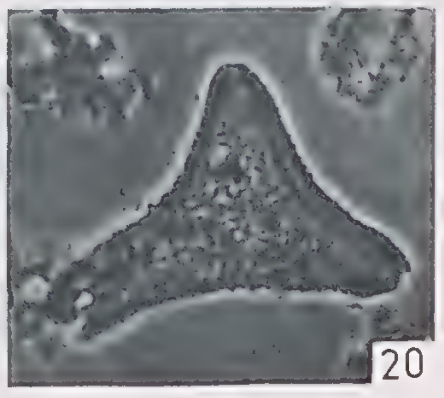


PLATE 5

PLATE 6

(All photographs approximately ×1000)

Figures 1, 3 and 6 —*Nothofagidites mataurensis* (Couper) comb. nov. (p. 11)

Figure 2 —*Nothofagidites astra* (Couper) comb. nov. (p. 10)

Figures 4, 5, 9 and 10 —*Nothofagidites* sp. 2 (p. 11)

Figures 7 and 8 —*Nothofagidites* sp. aff. *N. waipawaensis* (Couper) comb. nov. (p. 10)

Figure 11—*Nothofagidites* sp. 3 (p. 11)

Figure 12—*Nothofagidites suggatei* (Couper) comb. nov. (p. 10)

Figure 13—*Nothofagidites* sp. aff. *N. brachyspinulosa* (Cookson) Harris, 1965 (p. 10)

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Figure 15—*Nothofagidites falcata* (Cookson) comb. nov. (p. 11)

Figures 16 to 20 —*Retistephanocolpites* sp. aff. *R. reticulatus* (Couper) comb. nov. (p.11)

Figure 21—*Haloragacidites* sp. aff. *H. myriophylloides* Cookson & Pike, 1954 (p. 18)

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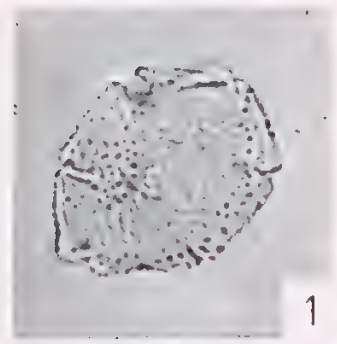
Figure 26—*Parsonsidites* sp. (p. 18)

Figure 27—*Malvacearumpollis estelae* (Germeraad, Hopping & Muller) comb. nov. (p.18)

Figures 28 and 29 —*Malvacipollis diversus* Harris, 1965 (p. 18)

Figure 30—*Restoniidites homeopunctatus* (McIntyre) Elsik, 1968 (p. 15)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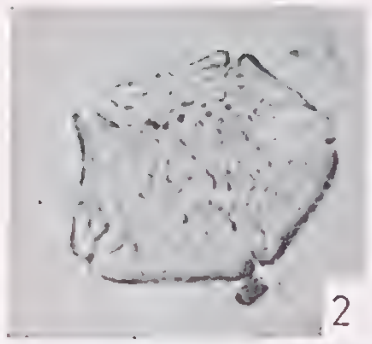
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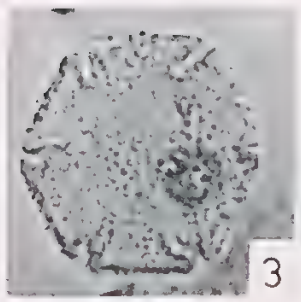
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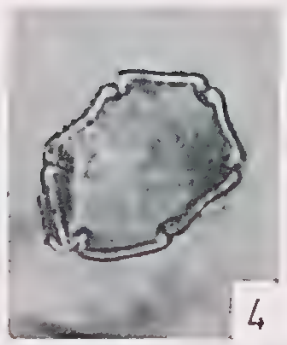
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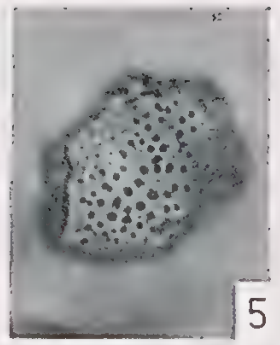
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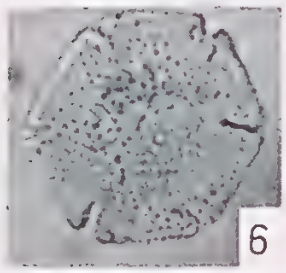
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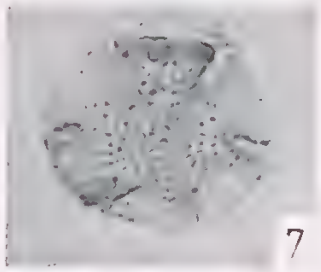
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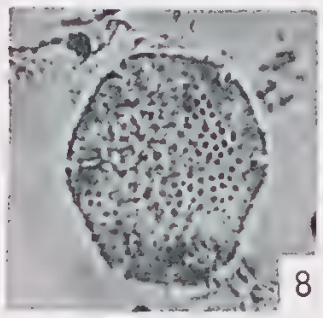
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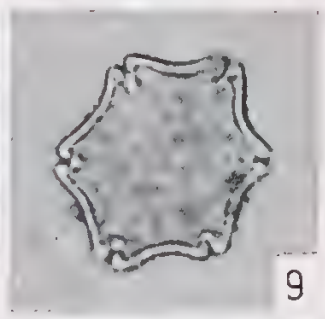
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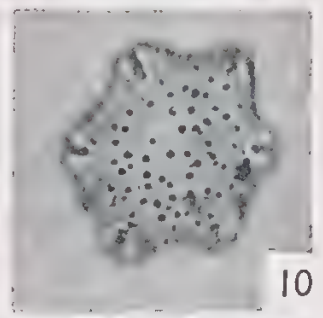
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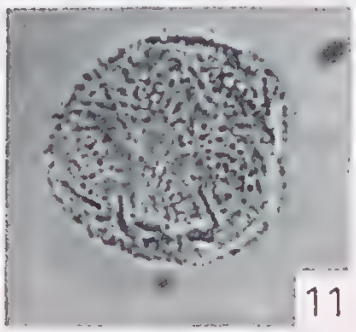
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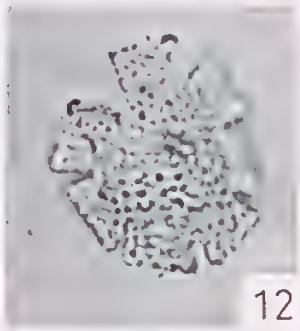
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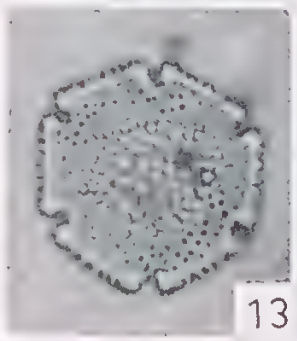
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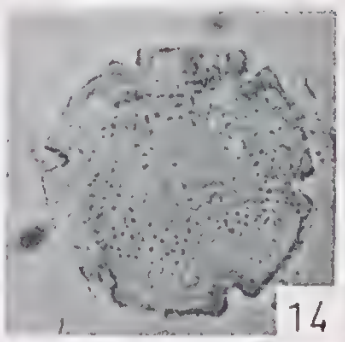
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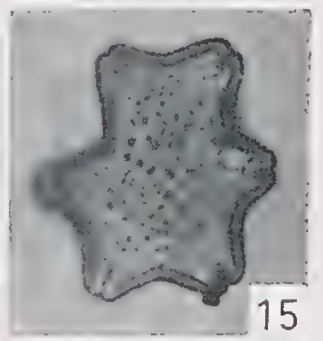
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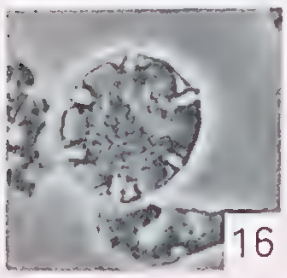
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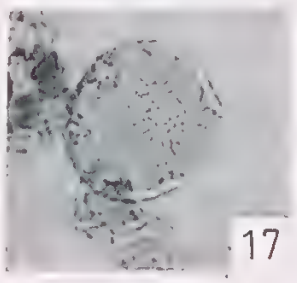
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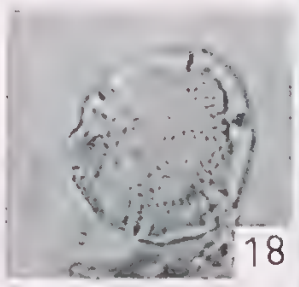
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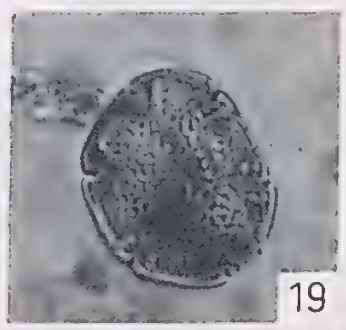
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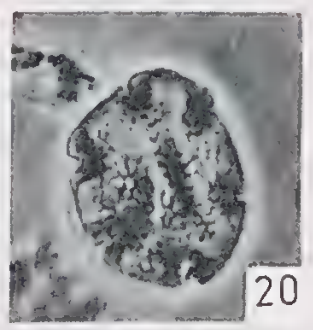
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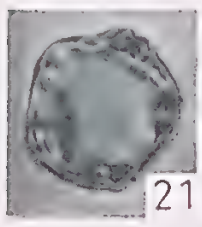
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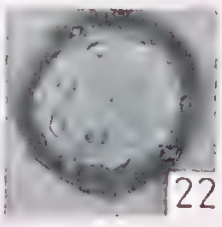
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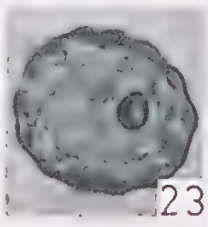
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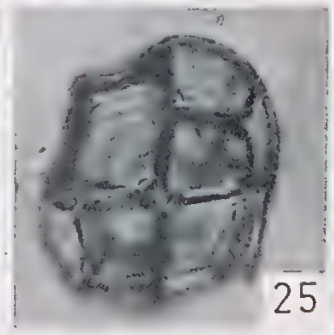
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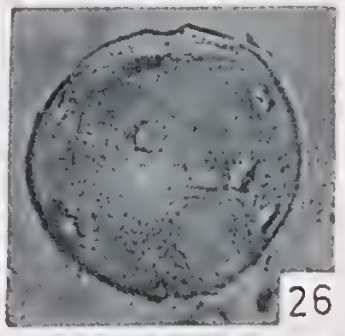
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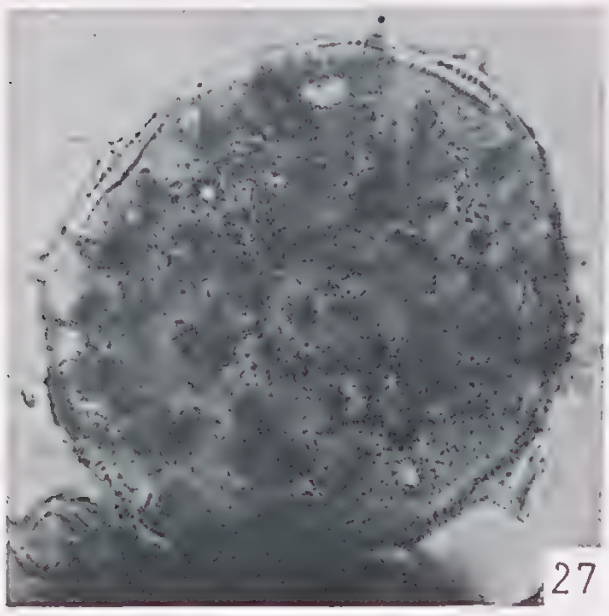
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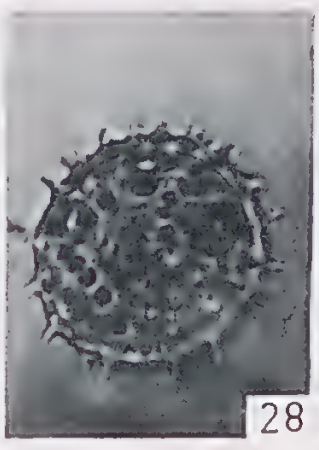
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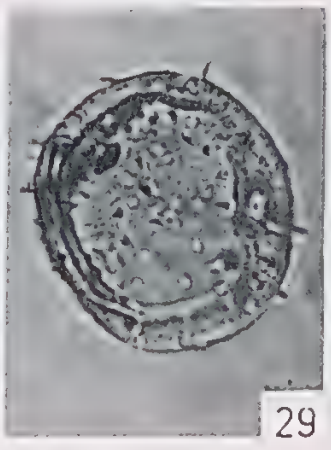
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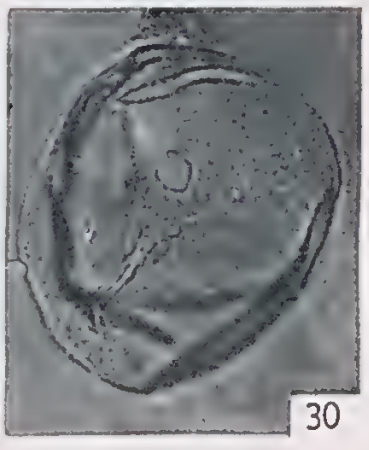
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PLATE 6

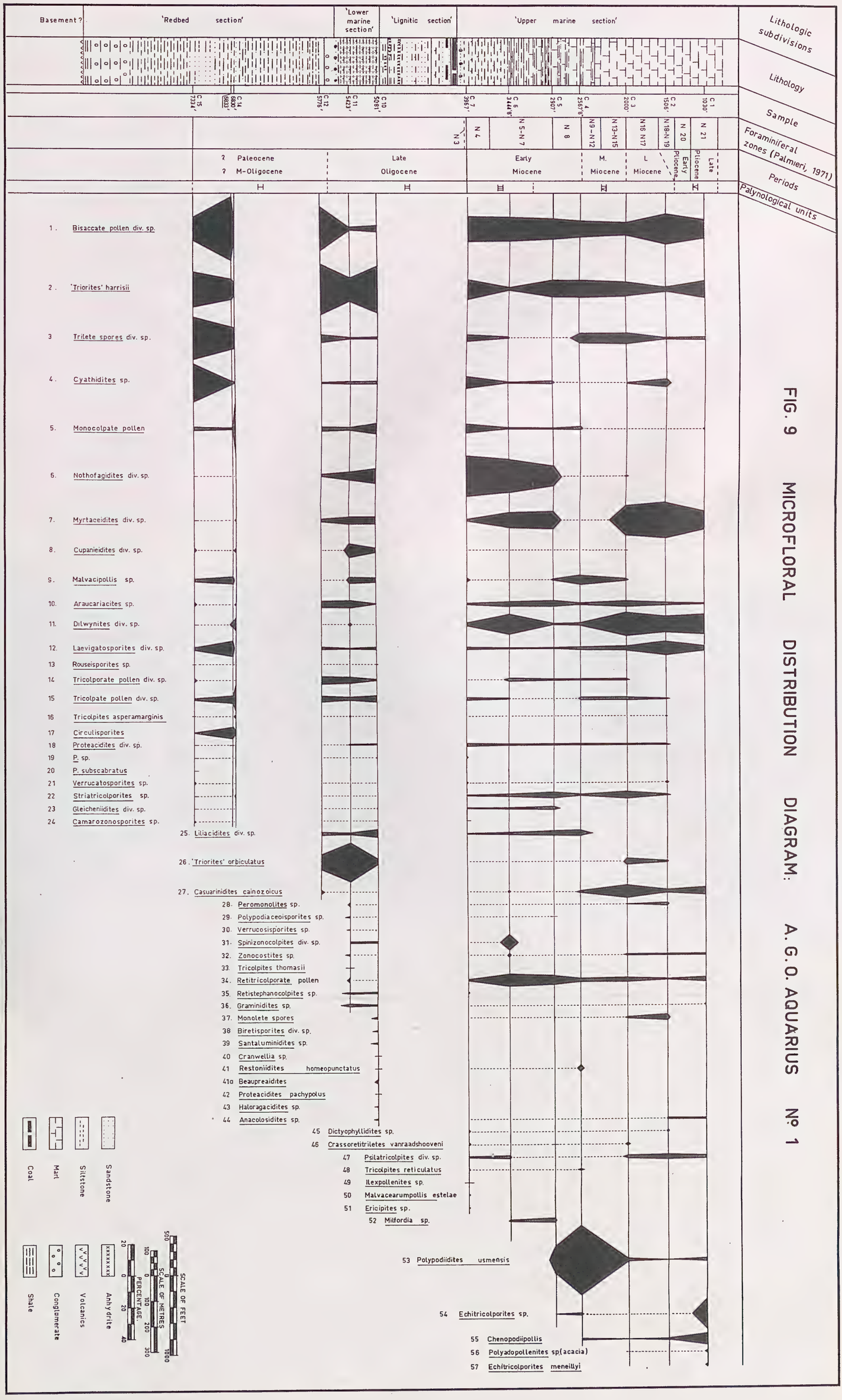

FIG. 9 MICROFLORAL DISTRIBUTION DIAGRAM: A. G. O. AQUARIUS Nº 1

NATIONAL MUSEUM
25 JUN 1973
OF VICTORIA

QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

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BRADORIIDS FROM THE *XYSTRIDURA* ZONE OF THE GEORGINA BASIN, QUEENSLAND

by
P. J. G. Fleming

Geological Survey of Queensland

BRISBANE
April, 1973

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SUMMARY

Nine species of Bradoriida from localities in the *Xystridura* Zone of the Georgina Basin of north western Queensland are described and illustrated. Four species are placed in previously established genera of Indianidae Ulrich and Bassler; *Indiana sipa* sp. nov., *Mononotella sestina* sp. nov., *Indota formosa* sp. nov. and *Indota* sp. *Bradoria* sp. is the only representative of Bradoriidae Matthew. A new genus, *Monasterium,* is erected for the reception of *Monasterium opiki* sp. nov., the type species, and *Monasterium dorium* sp. nov. *Monasterium* is tentatively assigned to Beyrichonidae Ulrich and Bassler. The remaining species are *Zepaera rete* sp. nov., the type species of the new genus *Zepaera,* and *Zepaera* sp. The family affiliations of *Zepaera* are uncertain.

The term Bradoriida Raymond is used, in preference to Archaeocopida Sylvester-Bradley. It is considered that present knowledge is insufficient to assign Bradoriida to Ostracoda. Morphologic studies indicate that most of the species must have moulted to achieve size increase in their carapaces. Furthermore, all species from one locality had carapaces joined along the hinge, and five of these had no gape of the posterior margins, and therefore no permanently projecting abdominal parts. The anterodorsal projection in *Monasterium* is in the position of an eye tubercle, but doubt is cast on such a function for it.

The palaeoecology of the six species from one locality is discussed, and it is concluded that they lived as infaunal benthos, restricted to a carbonate skeletal sand environment in shallow water of very high organic productivity. Organisms of unknown affinities were present which were capable of ingesting bradoriids and compacting their carapaces into coprolites.

INTRODUCTION

Bradoriids described in this paper are from four localities in the Beetle Creek Formation as mapped by Carter *et al.* (1957), Opik *et al.* (1958), de Keyser (1968) and Russell and Trueman (1971). All forms described in this paper except *Bradoria* sp., *Indota formosa* and *Indota* sp. are from a single sample of lime-phosphate rock from the Duchess phosphate field about 1 mile north of Mount Murray (approximately 21° 47'S, 139° 59'E). Although bradoriids are abundant in many samples from the phosphate field, it is convenient to base the descriptions entirely on this sample, because it contains numerous specimens of all the species so far recognized in the limestones, and the material is very well preserved. The sample consists of skeletal fragments, coprolites and collophane "pellets" in a sparry calcite cement.

There is a mixture of lithologies in the Mount Murray area, where there appears to be intertonguing of phosphorites and shales with lime-phosphates or phosphatic limestones. They form part of the Monastery Creek Member of the Beetle Creek Formation as mapped by Mines Exploration Pty Ltd, but the member, mentioned by Russell (1967), is not yet formally defined.

The fauna associated with the bradoriids consists of several species of minute (some definitely young) Inarticulata, sponge spicules, coprolites, numerous echinoderm fragments, *problematica,* eggs of ?Arthropoda, *Pagetia* sp., *Ptychagnostus* sp., and indeterminate trilobite fragments. Shergold (1968) indicated the age of a fauna from a similar horizon nearby (his locality D640) as basal *Ptychagnostus gibbus* Zone.

This work forms part of a study of the origin of the Georgina Basin phosphorites of Queensland.

Localities and Material: *Indota formosa* is from 1 mile west of No. 33 Bore, Duchess 1:250,000 Sheet area (21°57'S, 139°58'E approximately) at Bureau of Mineral Resources locality D 135. *Bradoria* sp. is from the Urandangie 1:250,000 Sheet area (21°41'S, 139°16'E approximately) at Bureau of Mineral Resources locality D41H. The specimens of *Indota formosa* and *Bradoria* sp. are in the Bureau of Mineral Resources collections (CPC numbers). *Indota* sp. comes from the bank of the Templeton River 100 yards downstream from Beetle Creek (20°37'S, 139°18'E). The locality for the remainder of the material is about 1 mile north of Mount Murray, Duchess 1:250,000 Sheet area (21°47'S, 139°59'E approximately). The sample from this locality is in the collection of the Geological Survey of Queensland (GSQF11981), together with most of the insoluble residue from which the specimens were recovered. All thin sections and whole specimens described are in the same repository.

Acknowledgements: My thanks are due to Mr. J. T. Woods for his continued support of the phosphorite project; to Prof. D. Hill of the University of Queensland for her helpful discussions; to Dr. J. M. Dickins for arranging the loan of material from the Bureau of Mineral Resources; and to Dr. A. A. Opik for much helpful discussion and criticism and for providing the specimen of *Bradoria* sp.

GLOSSARY OF NEW ZOOLOGICAL NAMES

dorium: neuter, arbitrary combination of letters.
formosa (Indota): Latin, handsome.
Monasterium: neuter, geographical, from Monastery Creek, Georgina Basin.
opiki: in honour of Dr. A. A. Opik.
rete: neuter, Latin, net.
sestina (Mononotella): arbitrary combination of letters.
sipa (Indiana): arbitrary combination of letters.
Zepaera: feminine, arbitrary combination of letters.

OTHER AUSTRALIAN BRADORIIDS

A census of Australian bradoriids compiled by Opik (1968) did not include any species from the lime-phosphate beds by name, but Shergold (1968) recorded several undetermined genera in acid-insoluble residues. The large *Bradoria* mentioned by Opik (1968) is possibly referrable to one of the forms described here under the generic designation *Indota.*

The Ordian forms described by Opik (1968), eleven species in all, are not closely related to the present fauna. Only representatives of Indianidae are common to both. Ordian indianids at Yelvertoft, *Indota* Opik and *Tropidiana* Opik, are shaped very differently from the Mount Murray indianids. The former have a border, and in one case, a groove, both lacking in the latter. Moreover, *Indota* and *Tropidiana* have definite dorsal margins on the valves, whereas the indianids from Mount Murray have only a faint division along the dorsum. Both *Indota* sp. and *I. formosa* sp. nov. of this paper differ from the Ordian type species *I. otica* Opik, in having carapaces ornamented by pits, though they are very weakly developed in *Indota* sp.

As well as lacking closely allied forms among described Australian species, the present bradoriids are not easily accommodated in the families mentioned by Opik (1968) and Sylvester-Bradley (1961). This subject is treated further in Systematic Descriptions.

MORPHOLOGY

(i) *Ornament* is displayed by five species, *Indota formosa, Indota* sp., *Zepaera rete, Monasterium dorium,* and *M. opiki.* The remainder are smooth.

Zepaera rete has a reticulate ornament over the body of the valve, including the ridges (pl. 2, figs 1, 4; pl. 3, figs 2-6). The minute polygonal ridges are developed on a very thin outer layer of shell which is commonly broken away, leaving a smooth looking carapace. This exfoliation is evidence of lamination of the shell and seems to bear some relationship to the state of chalkiness of the specimens. Those with ornament fully preserved appear to have suffered very little weathering, are lustrous and nearly transparent. On the double border of *Z. rete,* the ornament of polygons breaks down into randomly disposed tubercles (pl. 3, fig. 2). The tubercles are shortened ridges, not the central swellings shown in pl. 3, figs 4-5. Several examples show that small valves have slightly coarser ornament network than larger valves. The correlation between valve size and ornament strength suggests that at least two growth stages are represented.

Monasterium opiki has an ornament of low reticulate ridges forming polygons (pl. 3, fig. 7; pl. 4, figs 1-4), which are distributed over the whole surface. The extremely thin layer bearing the ornament is flaked off most specimens, leaving a surface which resembles pigskin in texture. Ornament is easily overlooked, even in well preserved individuals at magnifications less than about 25 times. In pl. 2, fig. 10, the low resolution of the optical system gives the ornament the appearance of tubercles.

The ornament of *M. dorium* consists of tiny raised tubercles. These are randomly disposed over the whole surface of the valve, but are more densely crowded near the margin beneath the level of the ridge extending back from the "eye". As in *Zepaera rete,* the very thin layer of shell bearing the ornament is peeled away in some specimens, leaving an apparently smooth shell.

Indota formosa has an ornament of closely spaced pits which are largest in the middle of the carapace, and very fine near the margins (pl. 1, fig. 12). The single

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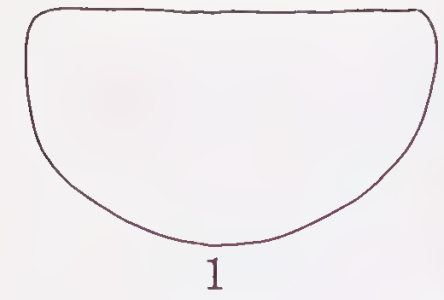
TEXT-FIGURE A

Bradoriid morphology. Drawings are composite reconstructions, some based on particular specimens as indicated:

1-2 *Indiana sipa* sp. nov. **1.** Outline of right side of carapace. **2.** Vertical cross section through carapace. **3-5** *Mononotella sestina* sp. nov. **3.** Outline of right side of carapace. **4.** Vertical cross section through carapace. **5.** Dorsal outline of carapace with free margins extending along the dorsum. **6.** *Indota* sp. Left side. Relation of marginal rim to dorsum not known. From GSQF11970. **7.** *Indota formosa* sp. nov. Left side. Relation of marginal rim to dorsum not known. From CPC13190. **8-9** *Zepaera rete* sp. nov. **8.** Right side. **9.** Vertical, partial cross section showing double marginal rim. **10-11** *Zepaera* sp. 10. Right side. **11.** Vertical partial cross section showing convex marginal rim. **12.** *Bradoria* sp. Right side. **13-14** *Monasterium opiki* sp. nov. **13.** Left side of carapace, early instar stage. From GSQF11965(10). **14.** Left side of carapace, largest instar stage known. From GSQF11965(10). **15-17** *Monasterium dorium* sp. nov. **15.** Left side of carapace, smallest instar stage known. From GSQF11965(9). **16.** Right side, largest instar stage known. **17.** Partial vertical cross section showing shape of hinge region.

(a) hollow antero-dorsal spine; (b) eye tubercle; base of spine in *Monasterium* (c) lateral ridges; (d) dorso-lateral inflation; (e) marginal ridge clearly defined in larger instars of *Monasterium opiki;* (f) marginal convex rim; (g) inner convex marginal rim in *Zepaera rete;* (h) rare swelling in examples of *Z. rete;* (i) median tubercle in *Zepaera* sp.; (j) postero dorsal swelling in *Zepaera* sp.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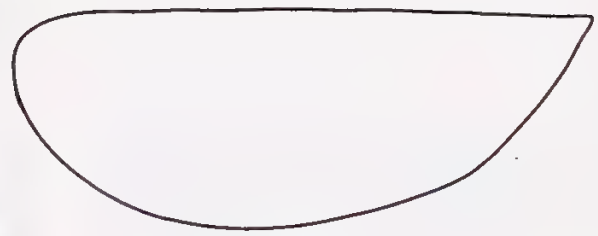
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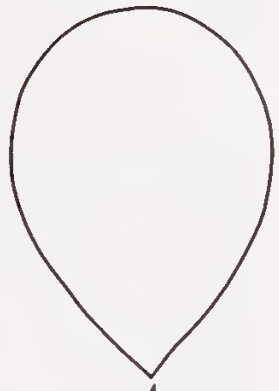
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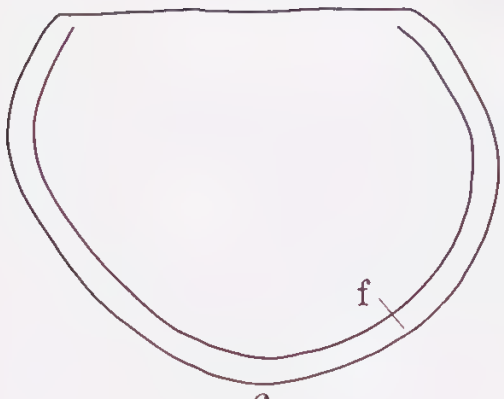

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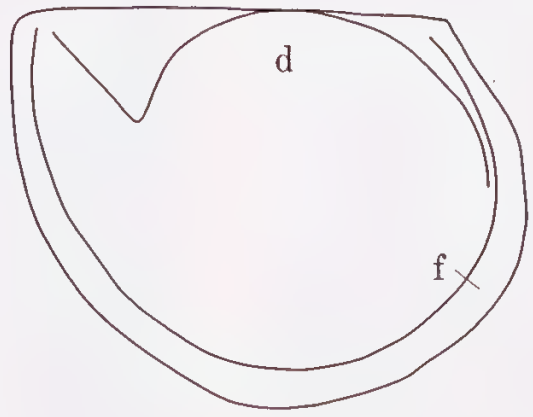

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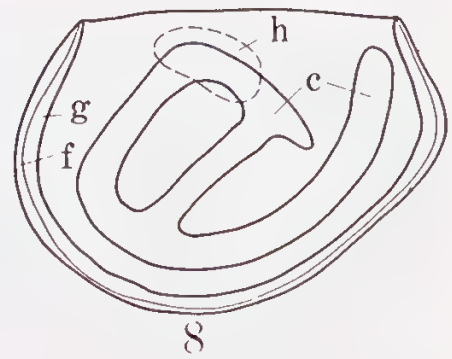

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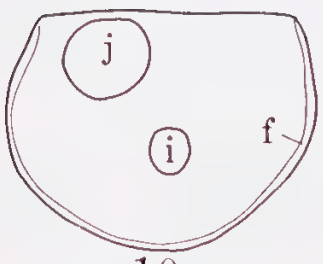

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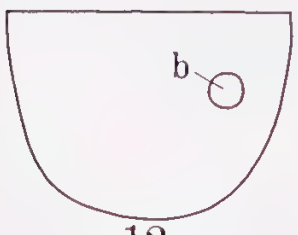

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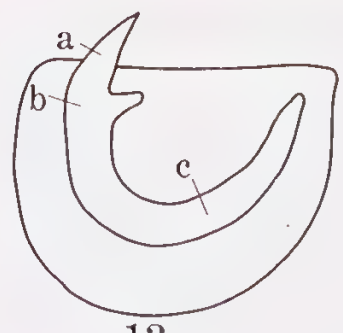

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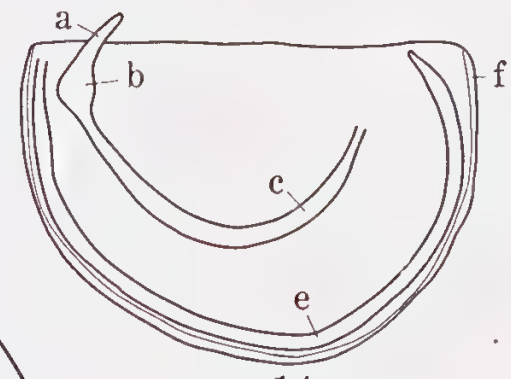

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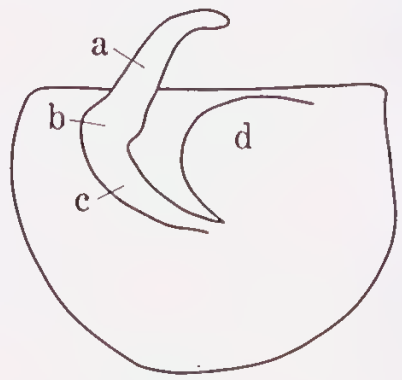

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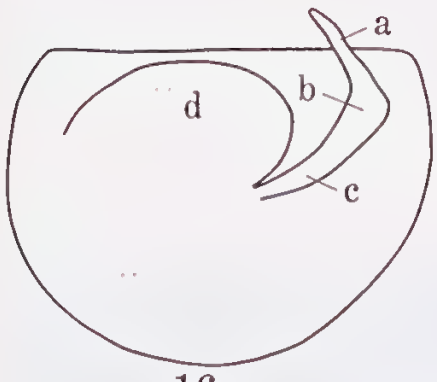

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TEXT FIGURE A
Explanation opposite

specimen of *Indota* sp. has similar pits near the rear margin, but the remainder seems, in its present state of preservation, to be smooth.

(ii) *Hingement* in all species from Mount Murray appears in scanning electron micrographs as a fine crack in the dorsum (pl. 3, figs 1 and 6). The light microscope reveals no line of division at all in *Indiana sipa* and *Mononotella sestina.* In specimens of *M. sestina* with slightly arched dorsal margins, the carapace halves are separated for some distance from the extremities in dorsal view (text-fig. 5). Light microscopy shows grooves, which are infolds of shell, in the hinge regions of species of *Zepaera* and *Monasterium.* The infold is quite shallow, and there is a fine line of division between carapace halves at the centre of the infold (pl. 3, fig. 6). The line of division in *Zepaera rete* is more definite than in *Mononotella sestina* (cf. figs 1 and 6, pl. 3), but even in *Z. rete,* ornament crosses the line asymmetrically. Hingement appears to be a simple folding of the carapace. This suggests that these organisms are in an early stage of development of the bivalved carapace.

Species from Mount Murray seldom occur as separated carapace halves. Opik (1968, p. 10) considered that the carapace halves of bradoriids, even when outspread, were joined fairly firmly. Movement, he suggested, was probably accomplished by flexibility and elasticity of the connective tissue. These interpretations are probably also applicable to species of *Zepaera* and *Monasterium,* and to *Mononotella sestina,* even though they may not be closely related to the Ordian forms.

No observations on the hinges of other species are possible because of their preservation.

(iii) *Posterior gape* occurred in several species discussed by Opik (1968). However, all species described herein lack posterior gape, with the very doubtful exception of *Mononotella sestina.* Specimens of *M. sestina* are usually distorted, and show an apparent front and rear gape. However, the presence of several undistorted individuals with completely closed margins suggests that no gape was originally present. Other species from the lime-phosphate beds can usually be shown to have closed completely, and probably the whole of the body could be withdrawn into the shell.

(iv) *Margins* of three kinds, plain, bordered, and thickened, are represented among the species described. *Monasterium opiki, M. dorium* and *Mononotella sestina* have plain margins, modified slightly by a near-marginal ridge in *M. opiki,* and in some specimens of *Mononotella sestina* by faint marginal thickening.

The margin of *Indiana sipa* lacks a doublure like the Palaeocopida, but is thickened by separation of two layers of shell and the introduction, or thickening, of a third layer. The marginal strengthening is of uniform size around the periphery of each valve.

Zepaera sp. has a convex, narrow border separated from the body of the valve by a groove. *Zepaera rete* has a complex double border. The strongly convex border inside a less convex outer border is not a valve ridge analogous to that in *Monasterium opiki,* but is purely a border feature.

Indota formosa and *Indota* sp. have convex borders similar to that of the type species *I. otica.*

(v) *"Eye tubercles"* are present in *Monasterium opiki, M. dorium,* and *Bradoria* sp. The larger swellings on the valves of *Zepaera* sp. are too far removed from the antero-dorsal position to merit consideration as eye spots. In *Monasterium opiki* and *M. dorium,* the structures take the form of long dorso-laterally extended hollow spines. The spines of most specimens are hollow tipped, but in better preserved individuals the termination of the spine, though sharp, is closed. Shell ornament extends almost to the ends of the spines (pl. 4, fig. 6). In *Monasterium dorium*, there is no ultra-smooth sensory tip on the spines. Therefore, it is doubtful that they are eye stalks.

(vi) *Shell structure* is difficult to observe, as all specimens in insoluble residues, and most of those seen in thin sections of lime-phosphates, are composed of collophane. Traces of three shell layers are present in most species, but only the very thin outer layer bearing the ornament is ever distinctive. One specimen, in a thin section of rock from the Mount Murray locality (GSQF11980), appears to have retained the original shell material. It is composed of three similar layers of a weakly birefringent apatite-like mineral (text-fig. B). The layers are each laminar, exhibit no cross-structure and, unlike the three layers in species figured by Andres (1969, figs 1, 3-5) are of equal thickness. Specimen GSQF11980, because of its size and shape, is a representative of either *Mononotella sestina* or *Monasterium opiki.* The former identification seems more probable since there is no suggestion of ornament on the outer layer. No other thin section, even from the same rock sample, contains carapaces with this shell composition. Collophane apparently replaces the original shell material and makes direct observation as to whether carapaces were divided at the hinge impossible.

TEXT-FIGURE B

Thin section. Transmitted plain light. X 250. Three laminated layers in a carapace of *Mononotella sestina* or *Monasterium opiki.* Layers separated by deformation at right end, and calcite cement introduced between layers.

(vii) *Pore canals* may be present in *Zepaera rete* (pl. 3, fig. 5) and *Monasterium dorium* (pl. 4, fig. 6). The minute holes in the surfaces of the species are randomly distributed, and are not known to penetrate even the outer layer.

PALAEOECOLOGY

Indota formosa is represented by only a few individuals in chert, while *Indota* sp. and *Bradoria* sp. are single specimens in shale, so there are insufficient data to consider the palaeoecology of these forms. The following discussion applies to the other species.

The other six bradoriid species have not been observed in quartz sand and silt beds, and only very rarely occur in any facies other than the lime-phosphate and siliceous-phosphorite facies of the Duchess phosphate field.

In the lime-phosphate facies, representatives of all six species are found in well sorted medium-grained collophane sands cemented by sparry calcite. Finer-grained sands contain recrystallized micrite matrix. The sand fraction consists of skeletal particles, micrite pellets, faeces, and grains of probable faecal origin. These sands are thought to be entirely of organic origin, and there are no terrigenous grains present. Petrologic and other palaeontologic work on these rocks, not yet published, suggests that they are shallow water, offshore, washed carbonate sands whose constituent grains were altered to collophane soon after deposition. The sands are interbedded with recrystallized carbonate muds in which bradoriids are extremely rare.

It is not known whether all species of the lime-phosphate facies occur in the siliceous phosphorites. In the siliceous rocks, carapaces are often broken into fragments, are usually altered without preservation of fine detail to collophane, and can be seen only in thin section, where identification is uncertain. However, *Indiana sipa, Mononotella sestina* and *Zepaera rete* have been recorded.

This correspondence in faunal composition, although incomplete, may be indicative of the presence of similar depositional environments in the lime-phosphate and siliceous-phosphorite facies. Evidence elaborated elsewhere (Fleming, in press) indicates that the siliceous phosphorites containing bradoriids are laterally equivalent to, and in fact were formed by, replacement of lime phosphates.

Bradoriid species under consideration were presumably provided with muscles which closed their carapaces against tension of the hinges. Further, it is reasonable to assume that the carapaces would open when the animal died or when moulting occurred. Carapaces in the phosphatic sands are usually closed. This might indicate burial of living animals. However, since closed carapaces are so common, a more likely deduction is that the animals lived as burrowers within the sediment, and that upon death or moulting, the carapaces were held closed by the weight of overlying sand. The rarity of bradoriids in lime mud beds and their abundance in sand beds is consistent with the hypothesis that these species lived as burrowers in sand. This is supported by the very good state of preservation of the remains. The lack of gape between the halves of the carapaces of most species suggests that appendages did not protrude.

Crushed bradoriid shells, in both lime-phosphates and siliceous phosphorites, are frequently incorporated in coprolites. Of the associated fauna, only the echinoderms are regarded as possible producers of faeces incorporating bradoriid shells. However, these primitive echinoderms are likely to have been suspension feeders, and it is therefore doubtful whether they were capable of ingesting bradoriids and compacting them into faeces. Bradoriids evidently provided food for larger organisms whose remains have not been found. The strongly phosphatic, calcareous and siliceous rocks are remarkably poor in larger fossils, which tend to be restricted to the non-phosphatic rocks of the *Xystridura* Zone in the Georgina Basin.

Bradoriids of the lime-phosphates and siliceous phosphorites are interpreted as benthonic, possibly infaunal, shallow water organisms which preferred carbonate sands to terrigenous clastic and carbonate mud environments. Evidently they shared the environment with echinoderms of unknown affinities, brachiopods, some trilobites, sponges, small hyolithids and gastropods, and a few other problematical organisms. The bradoriids were ingested by animals which were capable of compacting their shells into coprolites.

SYSTEMATIC DESCRIPTIONS

Order BRADORIIDA Raymond, 1935

Opik's (1968) arguments for retention of the ordinal name Bradoriida are accepted. Bradoriida (Bradorina) Raymond (1935) is equal in concept to the taxon for which Sylvester-Bradley (1961, p. 100) introduced the name Archaeocopida. Opik reserved his opinion on the subject of the subclass to which Bradoriida belongs and very little more light is shed on the question by this work.

The possibility that Bradoriida are affiliated with Phyllocarida seems quite strong when one considers the similarities of the carapaces of *Aristaluta gutta* Opik and *Aristozoe parabolica* Perner, as Opik (1968, p.17) pointed out. *Aristozoe* has a gape through which the elongate abodmen and telson protruded permanently. *Aristaluta* and other bradoriids, like *Zepaera* and *Monasterium* of this paper, are retroplenate, with no gape at the posterior. These forms were evidently able to accommodate the whole abdomen within their closed carapaces and this implies reduction of the abdomen. Other bradoriids (e.g. Opik, 1968, pp. 19, 30) have gapes at the rear of their carapaces, presumably allowing an elongate abdomen to protrude. This raises the possibility that two groups of different animals are presently included in Bradoriida. As far as the forms without gapes are concerned, affiliations with Palaeocopida cannot be ignored, especially when the palaeocopoid shapes of *Zepaera* and *Monasterium* are taken into consideration.

Andres (1969, p. 176) argued against placing the Bradoriida in Conchostraca as was done by Ulrich and Bassler (1931). Of Ulrich and Bassler's four reasons for not placing the bradoriids in Ostracoda, only the one concerning the difference in shell chemistry is constantly applicable throughout the Bradoriida, as pointed out by Andres (1969). It is thought that the difference in shell composition should not be considered an absolute bar, in the present state of knowledge, to possible relationship of the Bradoriida with the Palaeocopida. The two main groups of Brachiopoda differ similarly in shell composition.

Reasons advanced by Andres (1969) for acceptance of Bradoriida as Ostracoda are (i) the main difference between Bradoriida and Ostracoda may be accommodated in a hypothetical phylogeny; (ii) the three layered shell of Bradoriida is thick; (iii) bradoriids described by him have pore canals. Of these, the first is not positive evidence, and the second does not apply to the forms described here, nor probably to the material described by Opik (1968). The presence of pore canals appears to be strongly suggestive of relationships of the Bradoriida with the Ostracoda, but except for their doubtful presence in *Zepaera* and *Monasterium,* they have not been shown to occur in any bradoriids except those described by Andres.

Family INDIANIDAE Ulrich and Bassler, 1931.

Genera recently assigned to Indianidae by Sylvester-Bradley (1961) and Opik (1968) are characterized by smooth carapaces without eye tubercles. *Tropidiana* Opik, with a U-shaped ridge and groove, is the only exception. The three species hereunder are smooth and do not possess eye tubercles. However, the family now is interpreted to include forms of considerably different aspect. As more information on the included genera becomes available, it may be found that the family deserves subdivision.

Genus INDIANA Matthew, 1902

Type species (by subsequent designation Ulrich and Bassler, 1931, p. 68): *Indiana lippa* Matthew, Middle Cambrian, North America.

Indiana sipa sp. nov.

Pl. 1, figs 1-3; text—figs A1-2

1971 *Indiana* sp. In Hill, Playford and Woods, pl. Cm XIV, fig. 1.

Material: Numerous specimens with valves preserved. Holotype GSQF11965(17); paratypes GSQF11976 (15), GSQF11976(16).

Locality: 1 mile north of Mount Murray, approximately 21°47'S, 139°59'E.

Diagnosis: Dorsum straight, other margins making smooth, symmetrical curve. Surface smooth, no eye tubercles or other projections or markings, impunctate. Valves not separated, but hinged along more or less sharp upfold. Margins supplied with broad thickening of shell between inner and outer layers, giving inner layer convexity inwards along margin.

Description: Specimens about 0.5-1 mm in length. Height usually 40-50 per cent of length. Carapace smooth, impunctate. Shell very thin, but thickened marginally by a thickening of the intermediate layer (text—fig. A-2). This structure probably continues over the dorsum. Valves united along the dorsum, most specimens having a sharp up-fold. No gape when the valves are closed.

Remarks: Many valves are in a partly open position, suggesting possible resilience of the dorsal region in life, resembling the condition of the ligament in Pelecypoda.

Genus MONONOTELLA Ulrich and Bassler, 1931

Type species (by original designation): *Primitia? fusiformis* Matthew, Cambrian, North America.

Mononotella sestina sp. nov.

Pl. 1, figs 5-9; pl. 3, fig. 1; text—figs A3-5

1971 *Mononotella* sp. In Hill, Playford and Woods, pl. Cm XIV, figs 2-4.

Material: Many complete and broken carapaces. Holotype GSQF11965(16); paratype GSQF11976 (17).

Locality: About 1 mile north of Mount Murray, approximately 21°47'S, 139°59'E.

Diagnosis: Dorsum broadly rounded in cross section, usually straight in side view. Front acute, rear broadly rounded, strong retral swing. Smooth, impunctate, no eye tubercles, slightly thickened margin, no gape, undivided across dorsum, strongly inflated.

Description: Dorsum very broad; anterior very low. Front acute, swept back, and rear margin evenly rounded. Posterior end of specimens with arched hinge line, having commissure passing well forward into the dorsum. No gape. Shell completely smooth, impunctate, with no eye tubercles. Division between valves a faint crack (pl. 3, fig. 1). Shell very finely laminated, but number of layers not known. Margins slightly thickened, but a doublure apparently not present.

Remarks: This new species is placed in *Mononotella* Ulrich and Bassler, 1931, because of its undivided carapace and very strong retral swing similar to that of the type species. The shells are not as straight-backed as other species. A deep cleft of the commissure evidently provided for a more satisfactory opening by reducing the length of shell which has to bend. There appears to be a weakness along the hinge, because crushed specimens are frequently folded in that region. A possible representative of this species has a carapace consisting of three very thin laminae of equal thickness (text—fig. B).

Genus INDOTA Opik, 1968

Type species (by original designation): *Indota otica* Opik, Ordian, north-west Queensland.

Indota sp.

Pl. 1, figs 13-14; text—fig. A6

1971 *Indota* sp. Hill, Playford and Woods, pl. Cm XIV figs 10-11.

Material: One specimen, GSQF11970, consisting of moulds of both valves slightly displaced and crushed.

Locality: Bank of Templeton River, 100 metres downstream from Beetle Creek, 20°37′S, 139°18′E.

Description: About 13.5 mm long and 11-12 mm high, with a fairly short, apparently straight dorsal margin. Not very oblique, front and rear margins evenly rounded, anterior extremity about 3 mm below dorsal margin. Antero-ventral margin slightly convex. Dorsal angles wide, slight indentation of margin beneath posterior angle, but no spine present. Presence of posterior gape not determined. Rim fairly wide, convex, of more or less uniform breadth around entire margin, but perhaps not present along the dorsum. Relationship of rim to dorsal angles not observable. Rim separated by only a very slight furrow. Surface smooth, except for about six irregularly arranged minute pits on exterior of posterior border. Centrally situated mark less than 1 mm diameter may be a muscle scar.

Remarks: Indota sp. differs from the type species in its lesser retral swing, its slight marginal sinus below the postero-dorsal angle, and its surface pits. The absence of an eye spot is uncertain because of the preservation of this specimen.

Indota formosa sp. nov.

Pl. 1, figs 10-12; text—fig. A 7

Material: Holotype, CPC13191; other specimen CPC13190.

Locality: Bureau of Mineral Resources locality D135, approximately 21°57′S, 139°58′E.

Diagnosis: Shell height, length and straight dorsum approximately equal. Free margins broadly rounded with very slight sinus beneath obtuse postero-dorsal angle. Rim around free margins wide, strongly convex, separated by wide concave channel from body of shell. Ornament of closely spaced, hemispherical pits.

Description: Holotype 7 mm long and 5 mm high. Straight dorsal margin about 5 mm long. Modest retral swing, with rounded venter and posterior, very slight marginal sinus below obtuse postero-dorsal angle. Possible gaping posterior, but preservation inadequate to confirm observation. Wide marginal rim strongly convex, separated by deep, wide concavity from body of shell. Rim terminates at dorsal angles. Posterior two-thirds of shell and antero-dorsal corner inflated, with flatter area between. Body of shell ornamented by closely spaced, irregularly arranged, hemispherical pits. Pits on margin much smaller, more irregular in shape and arrangement, and more closely spaced. Gradation in pit arrangement from margin to middle of shell (pl. 1, fig. 12).

Remarks: This species differs from the type species in having a surface ornament of pits, a much lesser retral swing, and a smooth, broadly convex antero-ventral and ventral margin.

It is known from only three specimens in cherty shale west of the phosphatic rocks in the Mount Murray area. It has not been recognized in the lime-phosphate facies.

Indota sp., described above, seems to have a much smoother carapace.

Family BRADORIIDAE Matthew, 1903

Genus BRADORIA Matthew, 1899

Type species (by subsequent designation, Ulrich and Bassler, 1931, p. 12): *Bradoria scrutator* (Matthew), Lower Cambrian, Canada.

Bradoria sp.

Pl. 2, fig. 5; text—fig. A12

Material: CPC13192, internal mould of an incomplete right valve.

Locality: Bureau of Mineral Resources locality D41H, 21°41′S, 139°16′E.

Description: Valve about 1.3 mm long and 1 mm high. Dorsal margin straight, at greatest length of carapace. Free margins broadly, and probably smoothly, rounded. A very narrow, convex rim may be present around free margins. Carapace evenly and strongly inflated. Eye tubercle prominent, set almost at mid-height and well back from the anteroventral margin.

Remarks: The specimen is broken at the postero-dorsal extremity and in front of the eye tubercle, while the matrix is too coarse to determine whether the shell is punctate, or whether there is definitely a marginal rim.

In the low position of the eye tubercle, this specimen resembles the three species described by Opik (1968, pp. 22-24), but the tubercle is set even lower than in Opik's species.

Family INCERTAE SEDIS

Genus ZEPAERA gen. nov.

Type species: Zepaera rete gen. et sp. nov., *Xystridura* Zone, Middle Cambrian, Georgina Basin, Queensland.

Diagnosis: Straight-backed, deep, marked retral swing. Margins broadly curved, entire, dorsal angles obtuse. Much inflated. No doublure. No eye tubercles. Wide ridge on each flank extending from antero-dorsal region in a broad sweep above the free margin, and with a median branch extending up from its ventral part.

Remarks: Ophiosema Opik, 1968 resembles this genus in shape and the presence of a lateral curved ridge, but differs by the presence of an eye tubercle, bordered dorsal margin, pustulose ornament and spicate dorsal extremities. There is no close resemblance to any other genus of bradoriids, though the combination of characters suggests relationship with the family Comptalutidae Opik.

Zepaera rete sp. nov.

Pl. 1, figs 18-19; pl. 2, figs 1-4; text—figs A8-9

1971 Gen. et sp. nov. In Hill, Playford and Woods, pl. Cm XIV, figs 6-9.

Material: Numerous specimens. Holotype GSQF11976(9); paratypes, GSQF11976(3), GSQF11976(8).

Locality: 1 mile north of Mount Murray, approximately 21°47'S, 139°59'E.

Diagnosis: Double marginal rim. Ornament a fine network of ridges, pustulose on marginal rim.

Description: Dorsal angles obtuse, with no spication. No eye tubercle and no posterior gape. Double marginal rim (text—fig. A9) peters out at angles, and is marked off from body of carapace by a sharp change of slope Marginal rim forming valve margin nearly flat. Marginal rim immediately outside this very convex, wider than preceding rim, and separated from it by a groove. Groove along hinge line a downfold of shell, in the base of which is a fine crack separating carapace halves. Ornament extends without interruption across the crack. Main ridge on flank extends from antero-dorsal region in a broad sweep more or less parallel to free margin. Ridge bent sharply upwards and forwards at about one quarter of shell length from the posterior, terminating near the dorsum. A branch parallel to its posterior parts arises near its venter. Upper extremity of posterior end of ridge seems to extend in some specimens towards upper extremity of branch ridge. Whole ridge comparatively finer and more clearly delimited in large specimens. Ridges and convex borders concave on inner surface, and not involving thickening of carapace. Two or three specimens have rather indistinct ridges in upper median parts of valves, with an unusual bulge on the postero-dorsal area of main ridge (text—fig. A8, h). Minute pits on the exterior of one specimen may be pore canals. Ornament very fine, covering entire carapace, and consisting of a reticulate net of ridges arranged in minute polygons (pl. 2, figs 1,4; pl. 3, figs 2-6). On borders, ornament represented only by pustules. Ornament frequently preserved, although the thin ornament-bearing layer completely exfoliated in many specimens, leaving an apparently smooth surface.

Remarks: The fine net-like ornament resembles that of *Tuzoia* Walcott, 1912. The distinctiveness of the three carapace sizes among the material suggests that three moult stages are present. Larger specimens have slightly finer ornament than smaller ones. As it would not be possible for the net-like ornament to become finer as the carapace grew larger, growth must have occurred by moulting. Specimens are usually preserved with valves closed.

The bulge on the postero-dorsal part of the main ridge (text—fig. A8, h) was observed in very few individuals. These specimens are otherwise identical with the type material. It is possible that the bulges had a reproductive function. However, they are developed on only a small number of individuals, each of which is the middle instar stage, not the largest moult size as might be expected if the bulges were reproductive.

Zepaera sp.

Pl. 1, figs 15-17; text—figs A10-11

Material: Very rare, four specimens only. Described and figured specimen GSQF11965(17).

Description: Dorsal margin straight, retral swings light, strongly inflated. Available specimens very thin, with no evidence of ornament. Border very narrow, convex, single, marked off by a groove. A small tubercle in middle of valves, and a larger bulge in a postero-dorsal positial.

Remarks: The small number of examples makes it necessary to apply open nomenclature to this species. It is placed in *Zepaera* because of its shape, border, and lack of an eye tubercle. However, when more is known of its morphology, a new genus may be needed for its reception. *Indota otica* Opik (1968, p. 9) has a border, but the present species does not have the strong retral swing of that species.

Family BEYRICHONIDAE

Ulrich and Bassler, 1931

Remarks: The new genus *Monasterium* proposed below is tentatively placed in this family because it has certain features in common with *Beyrichona* Matthew. These features are:— (a) possession of eye tubercles (although greatly exaggerated in these species); (b) complete closure of margins (*fide* Ulrich and Bassler, 1931, p. 42); (c) depression of the area behind the eye tubercle. However, in other respects elaborated below it differs from *Beyrichona.*

Genus MONASTERIUM nov.

Type species: Monasterium opiki gen. et sp. nov., *Xystridura Zone,* Middle Cambrian, Georgina Basin, Queensland.

Diagnosis: Straight backed, margins evenly rounded, almost without retral swing, margins closed all round, no border. Strong eye tubercle with ridge extending posteriorly from it. Depressed area behind eye tubercle. Additional ridges and postero-dorsal spike present or absent.

Remarks: Beyrichona appears to be the only known genus which resembles *Monasterium.* However, the former differs in shape, ornament, possession of a border, and lesser development of the eye tubercle. The long, horn-like eye tubercle seems to be unique, although such a structure may have been overlooked because of breakage in other material. The horn is frequently broken off near its base, leaving a protuberance indistinguishable from any other eye tubercle in moulds.

Monasterium opiki sp. nov.

Pl. 2, figs 6-12; pl. 3, fig. 7; pl. 4, figs 1-4; text—figs A13-14

1971 Beyrichonidae gen. et sp. nov. In Hill, Playford and Woods, pl. Cm XIV, figs 12-14.

Material: Very abundant, usually bent and broken by compaction of sediment. Holotype GSQF11965(10); paratypes GSQF11965(4), GSQF11965(11), GSQF11965(15).

Locality: About 1 mile north of Mount Murray, approximately 21°47′S, 139°59′E.

Diagnosis: Postero-dorsal spike short, directed backward. Narrow ridge clost and parallel to the entire free margins. Ornament a very fine network of ridges.

Description: Dorsum straight. Inflation strong. Very weakly retroplenate. Margins not gaping in closed carapaces. Postero-dorsal angle bearing a short, blunt spike. Almost no retral swing. Smaller specimens more inflated than larger ones and with comparatively thick shells. Carapace of larger growth stages very thin. No doublure and no border. Ornament a very fine, randomly distributed network of fine ridges forming polygons. Network of ridges may extend along horns, though ridges are so fine that they can be seen with difficulty even on body of carapace. Ornament-bearing layer flakes off quite easily, leaving an indistinctly pitted surface. Area behind the horn depressed, forming a broad sulcus. Marginal ridge poorly defined in small growth stages, but very clear in larger specimens. Marginal ridge originates near antero-dorsal angle and runs parallel to and near free margin. Near postero-dorsal angle ridge swings around in an antero-dorsal direction (text—fig. A14, e). Another ridge originates at the horn and runs parallel to the margin before disappearing posteriorly about three-quarters along valve (text—fig. A13, c; A14, c). Horn, in the position of an eye tubercle, an elongate, tapered, hollow spike. Horn usually about one-third of shell length, apparently terminating in a finely rounded tip. Attitude of carriage probably upward, outward, and slightly backward. Two valves joined by a narrow downfold in which there is a very fine crack.

Remarks: This species is quite distinct from *Monasterium dorium* by virtue of its marginal ridge, posterior spike and network ornament. The downfold along the dorsum is narrower than that in *Zepaera rete.*

Monasterium opiki is very abundant in the sample and in other material from the phosphatic limestones. Possibly five growth stages are represented, but there is some overlap between the sizes, and the preservation is not good enough to correlate changes in other features with sizes. It is not as resistant to compaction as most other species, and it frequently occurs flattened among other particles in the sediment.

Monasterium dorium sp. nov.

Pl. 2, figs 13-15; pl. 4, figs 5-7; text—figs A15-17

1971 Beyrichonidae gen. et sp. nov. In Hill, Playford and Woods, pl. Cm XIV, figs 15-18.

Material: Rather rare in the described sample. About a dozen specimens form the basis of this description, though more are known. Holotype GSQF11965(8); paratype GSQF11965(9).

Locality: About 1 mile north of Mount Murray, approximately 21°47′S, 139°59′E.

Diagnosis: No spike on postero-dorsal corner. Carapace without ridges other than a short one originating at base of horn. Distinct granular ornament, coarsest in postero-ventral region.

Description: Dorsum straight. Retroplenate, weak retral swing. Sulcus behind horn present. Lobe forming main posterior part of shell quite strongly inflated (text—fig. A 15, d; A 16, d). Inflation strong, decreasing evenly over shell to venter. Margins tightly closed all round. Main lobe separated from dorsal margin by a flatter area which is continuous with sulcus. Only ridge on carapace feeble, extending down and back from horn base, and passing smoothly into main lobe (text—fig. A 15, c; A 16, c). Ridge delimits sulcus anteriorly. No properly defined border, though margins may be slightly thickened. Minute pits on the outside of the shell may be pore canals. Horn similar to than in *M. opiki.* Attitude probably similar. Ornament, of widely spaced granules, more closely spaced near margins than over rest of carapace, borne by a very thin outer layer which exfoliates leaving an apparently smooth shell. One well preserved specimen with ornament extending almost to end of the horn, which evidently lacks a sensory tip (pl. 4, fig. 6). At least four instar stages known (pl. 2, figs 13-15). Hinge marked by a very fine groove.

Remarks: This species resembles *Monasterium opiki* in shape and ornament and in possession of an elongate antero-dorsal horn, but does not have a spicate postero-dorsal extremity as in *M. opiki.* The ornament is different from that of *M. opiki,* and a near-marginal ridge is absent.

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EXPLANATION OF PLATE 1

1-3 *Indiana sipa* sp. nov. **1.** Exterior of right side of carapace. Holotype GSQF11965(17). Mount Murray. X 60. **2.** Part of exterior of right side of carapace (upper left), and part of interior of left side, showing thickened interior rim. Paratype GSQF11976(15). Mount Murray. X 50. **3.** Open carapace, line of hingement not marked by any surface feature. Paratype GSQF11976(16). Mount Murray. X 50. ¶ **4.** *Indiana sipa?* Left view of carapace with anterior tip bent upward. These shapes, which occur frequently, may be distorted individuals of *I. sipa.* GSQF11976(16). Mount Murray. X 55.

5-9 *Mononotella sestina* sp. nov. **5.** Dorsal view of carapace. Line of hingement not marked by any surface feature, except groove at each end (anterior present, posterior end of specimen broken). Paratype GSQF11976(17). Mount Murray. X 35. **6.** Oblique dorsal view, showing slight fold along the hingeline, but no separation. GSQF11976 (16). Mount Murray. X 55. **7.** Right side of carapace, anterior shape complete. Holotype GSQF11965(16). Mount Murray. X 30. **8.** Crushed right valve, anterior broken, posterior complete. GSQF11976(11). Mount Murray. X 30. **9.** Right side of carapace, slightly crushed, showing apparent strengthening of the rim. GSQF11965(16). Mount Murray. X 30.

10-12 *Indota formosa* sp. nov. **10.** Left side of carapace, crushed, but showing position of depressed antero-dorsal area. Rim incomplete on front half of carapace. Latex cast. CPC13190. Locality D135. X 7.5. **11.** Left view of left and right sides of carapace slightly displaced, showing interior of venter and posterior of right side of carapace. Latex cast. CPC13191, holotype. Locality D135. X 8. **12.** Surface of fig. 11 enlarged to show ornament of pits decreasing in size, but increasing in number, towards and across convex border. Latex cast. X 16.

13-14 *Indota* sp. Two sides of carapace slightly displaced, and pressed together. Lowest part of specimen is convex rim of right side of carapace. Rim of left side of carapace impressed above mould of rim of right side. GSQF11970 a & b. Templeton River, 100 metres downstream from Beetle Creek. X 3.

15-17 *Zepaera* sp. **15.** Right side of carapace with central protuberance and postero-dorsal swelling. GSQF11965(17). Mount Murray. X 40. **16.** Oblique dorsal view over left side of carapace. Same specimen. X 30. **17.** Ventral view, showing strongly convex, narrow marginal rim. GSQF11976 (14). Mount Murray. X 65.

18-19 *Zepaera rete* gen. et sp. nov. **18.** Left side of carapace of large, worn specimen with narrow ridges and rim. GSQF11965(11). Mount Murray. X 40. **19.** Oblique dorsal view over left side of carapace showing groove along hingeline. GSQF11965(14). Mount Murray. X 100.

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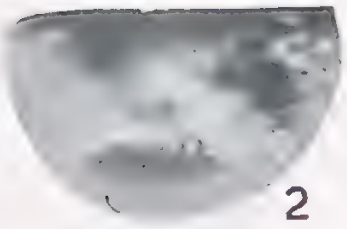
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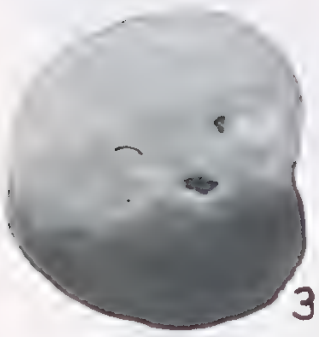
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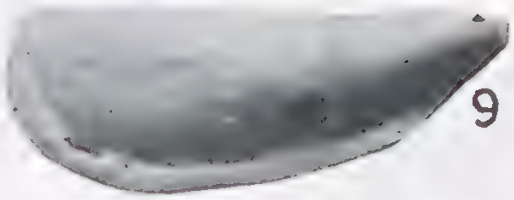
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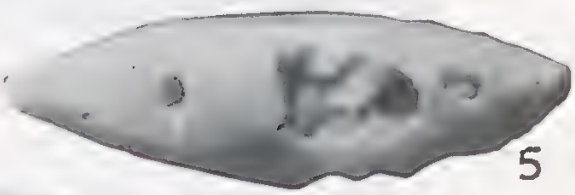
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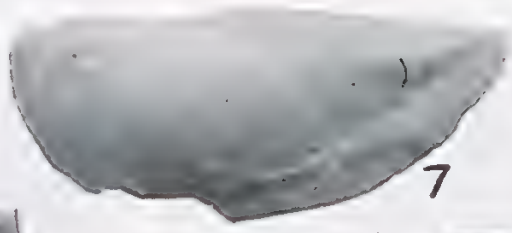
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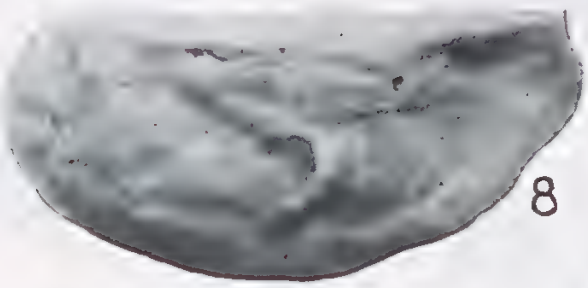
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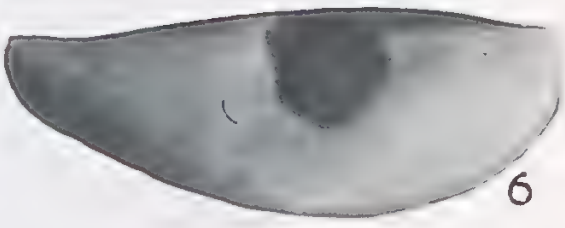
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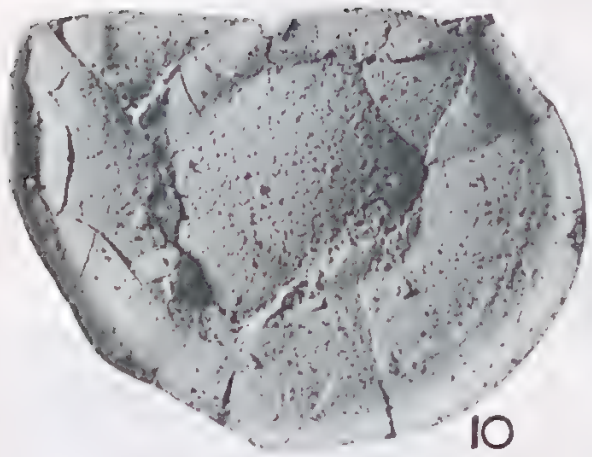
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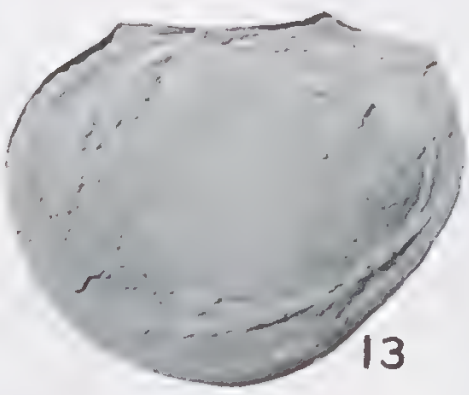
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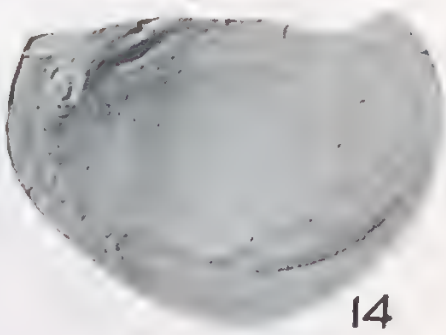
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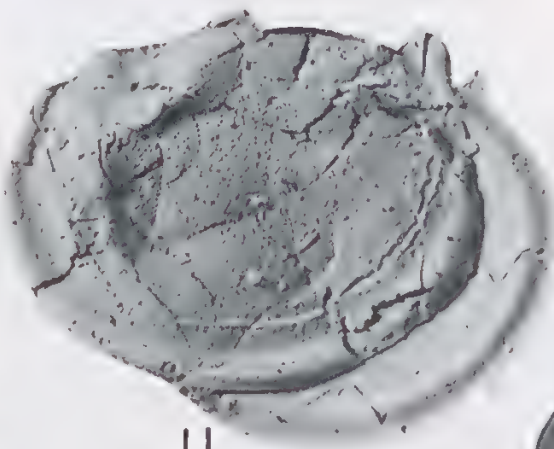
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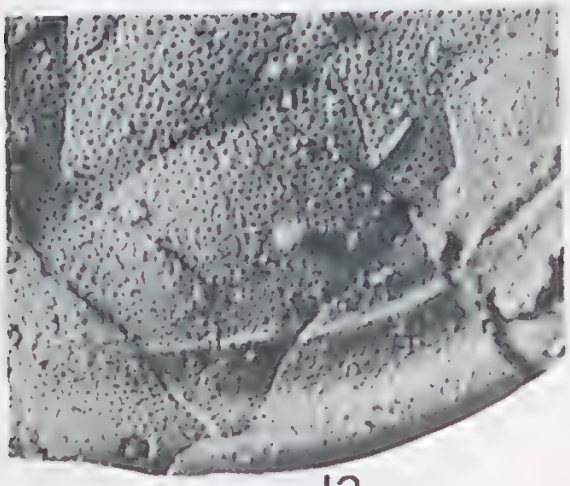
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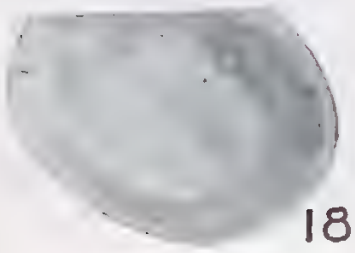
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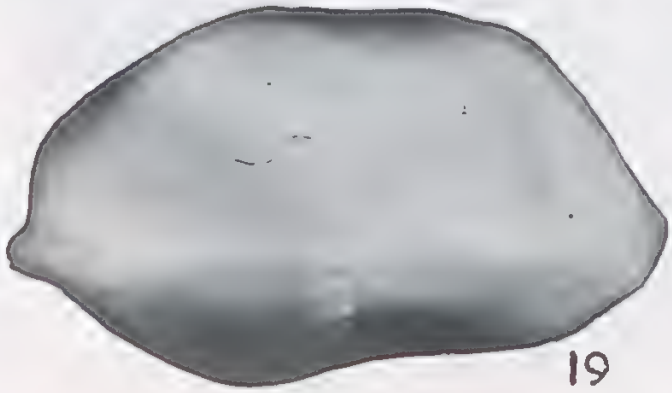
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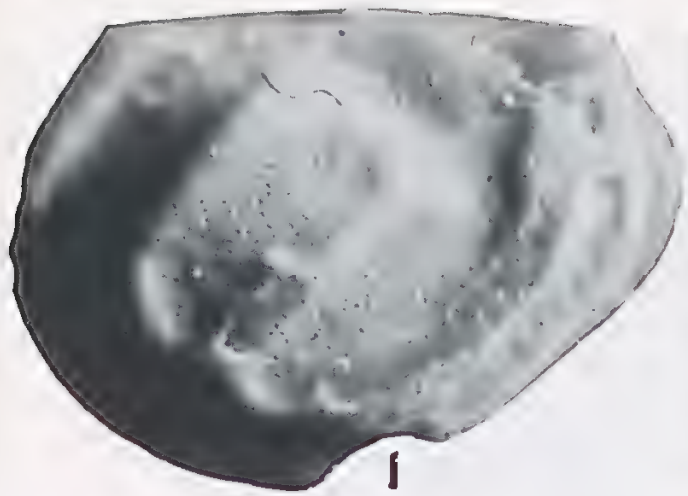
PLATE 1

EXPLANATION OF PLATE 2

1-4 *Zepaera rete* gen. et sp. nov. **1.** Exterior of right side of carapace of specimen of second of three instar stages known. Ornament only on thin outer layer which is peeling off on ridges. GSQF11976(3). Mount Murray. X 70. **2.** Ventral view of closed carapace, showing double border. GSQF11976(8). Mount Murray. X 70. **3.** Two specimens of smallest instar stage known for the species, lit together from different angles, to show the disposition of the comparatively strong ridges. GSQF11976(9). Mount Murray. X 35. **4.** High resolution view of specimen b of fig. 3, to show net-like ornament which occurs over whole surface of carapace. Ridge out of focus because of high lens aperture. GSQF11976(9). Mount Murray. X 90. **5.** *Bradoria* sp. Internal mould of right side of carapace with tubercle near front margin. CPC13192. Locality D41H X 20.

6-12 *Monasterium opiki* gen. et sp. nov. **6.** Left side of carapace of first (smallest) instar stage known, with weak ridge, but long antero-dorsal horn. Paratype GSQF11965(4). Mount Murray. X 30. **7.** Left side of second instar stage of species known, showing thin, but more distinct ridge, and distinct border ridge. GSQF11965(15). Mount Murray. X 50. **8.** Third instar known, with shape approaching that of largest instar (figs 9 and 10). Holotype GSQF11965(10). Mount Murray. X 50. **9.** Fourth and largest instar of species known, with very thin ridges and fine, evenly disposed, granular ornament. Antero-dorsal horn broken off at base. Paratype GSQF11965(4). Mount Murray. X 35. **10.** Same, X 70. **11.** Antero-dorsal horn of species, much enlarged, showing shape of tip, and very fine granular ornament. GSQF11965(15). Mount Murray. X 60. **12.** Detached antero-dorsal horn, showing resemblance to a conodont. GSQF11965(15). Mount Murray. X 30.

13-15 *Monasterium dorium* gen. et sp. nov. **13.** Third of the four instar stages known, right view of carapace with antero-dorsal horn broken off below base. Paratype GSQF11965(9). Mount Murray. X 30. **14.** Fourth and largest (lower) and second (upper) instars, lit together to show shape. Horn broken off at base in small carapace; similarly in large carapace, but there the break covered over by secondary depost. Ornament of fine, widely spaced granules, becoming more closely spaced near margin. Larger specimen holotype, smaller paratype. GSQF11965(9). Mount Murray. X 30. **15.** First (smallest) instar known, with antero-dorsal horn complete, and granular ornament extending to its tip. Paratype GSQF11965(9). Mount Murray. X 60.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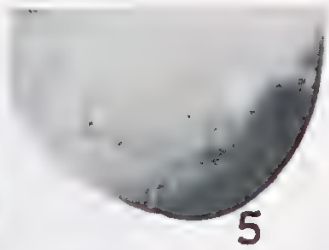
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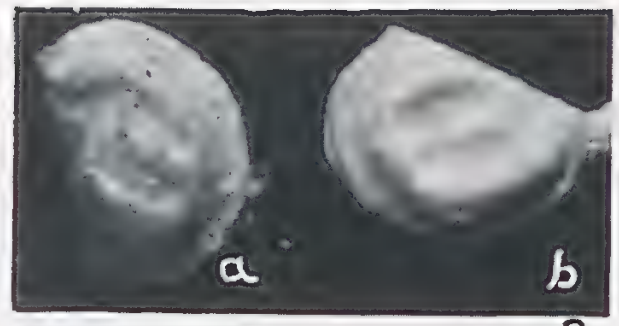

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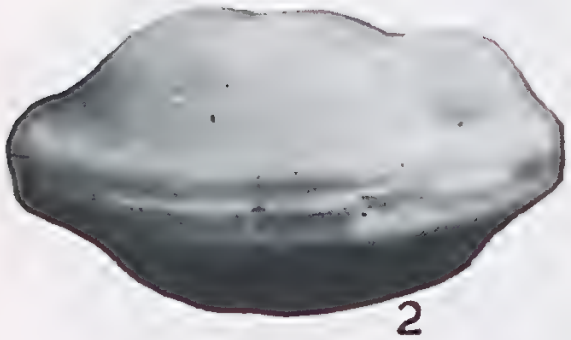
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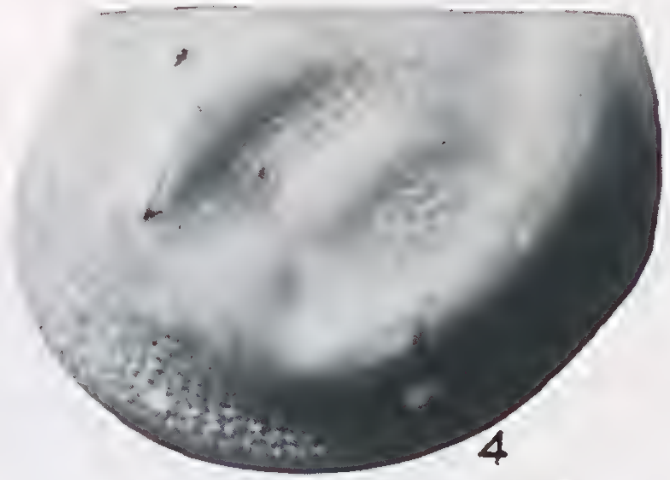
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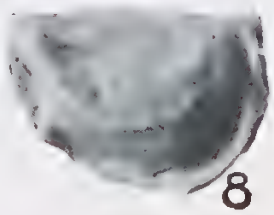
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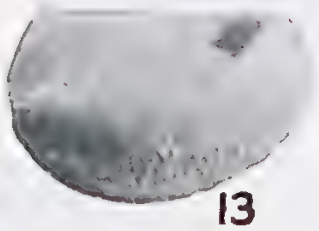
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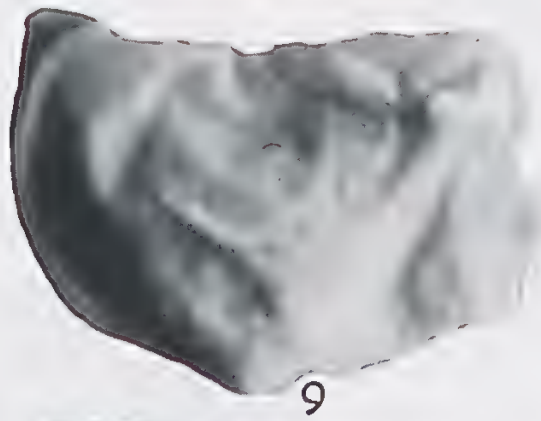
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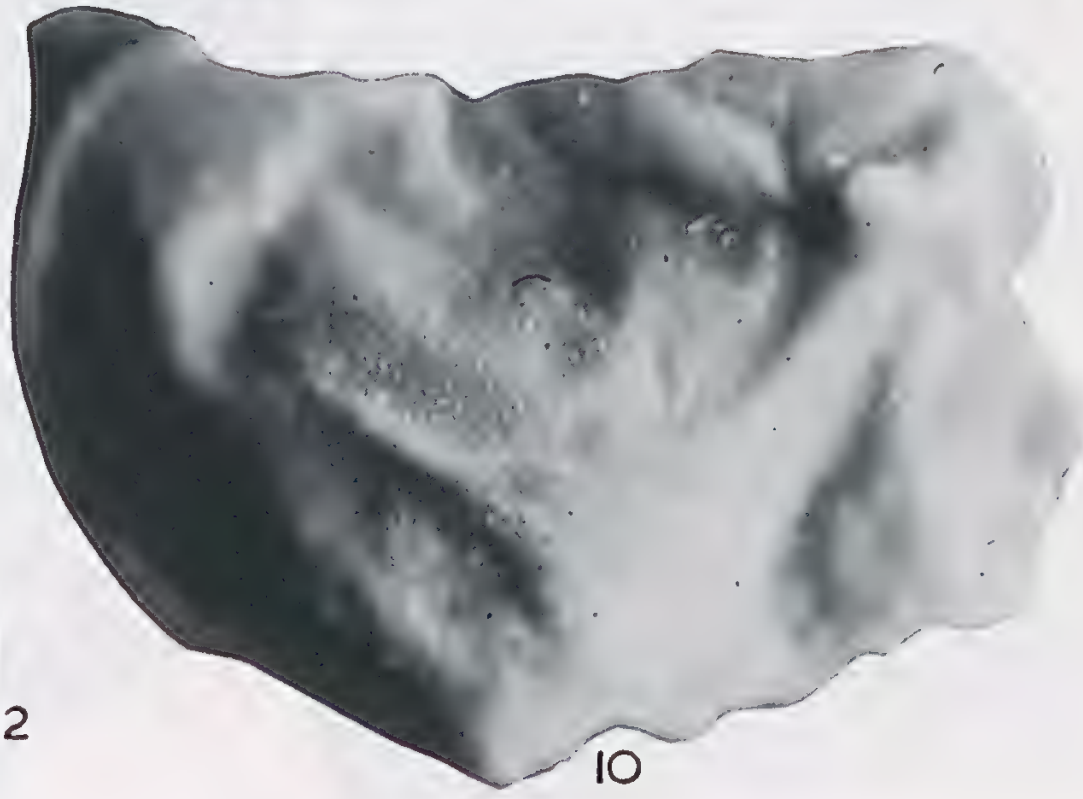
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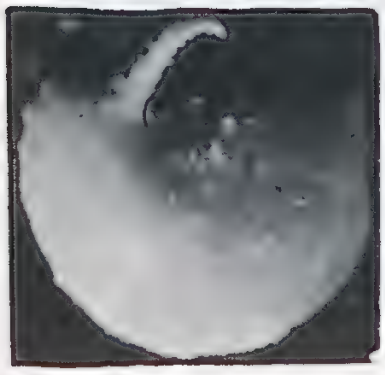
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PLATE 2

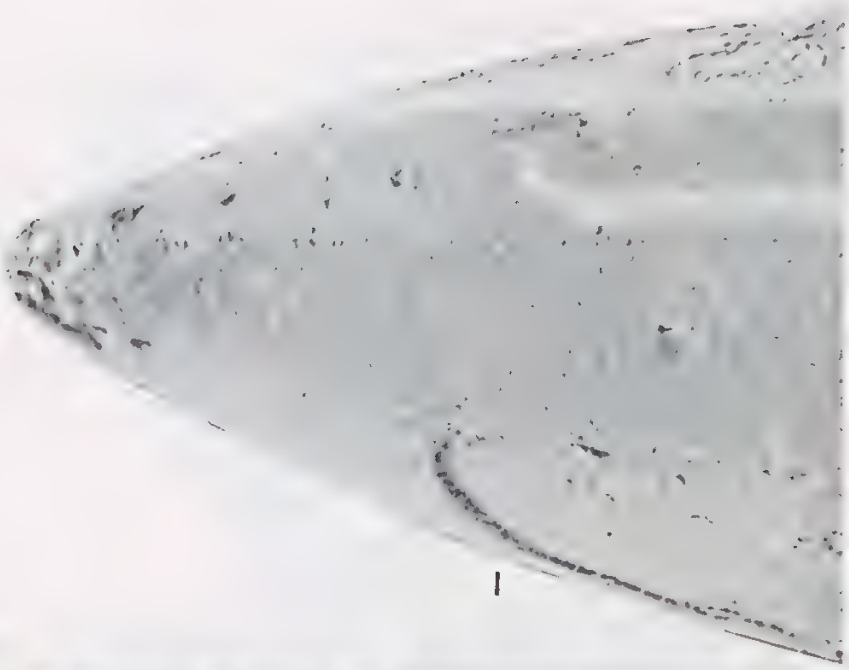
EXPLANATION OF PLATE 3

(All figures scanning electron micrographs. Magnifications approximate)

1. *Mononotella sestina* sp. nov. Dorsal view of anterior end of carapace showing faint line of division between carapace halves. GSQF11985 (5). Mount Murray. X 280.

2-6 *Zepaera rete* gen. et sp. nov. **2.** Oblique ventral view of second smallest instar. The network ornament breaks up into pustules near the ventral margin. Ornament-bearing layer broken off on ridge. GSQF11985(9). Mount Murray. X 170. **3.** Oblique dorsal view of second smallest instar. Ornament-bearing layer broken off on posterior ridge. Ornament uniform over upper parts of carapace. GSQF11985 (8). Mount Murray. X 190. **4, 5.** Two different enlargements of ornament on specimen of fig. 3. Each polygon surrounded by ridges and with central pustule. White grains are dust. Small holes which may be pore canals are seen in fig. 5; notably on pustule below centre. 4, X 800; 5, X 3000. **6.** Anterior end of hinge region of specimen of fig. 3. Carapace with shallow channel along hingeline, and very fine groove separating carapace halves. Ornament continuous across hingeline, polygons not symmetrical about hinge. X 500.

7. *Monasterium opiki* gen. et sp. nov. Oblique ventral view of right side of crushed carapace showing network ornament, base of antero-dorsal horn, and ridge. GSQF11985(16). Mount Murray. X 100.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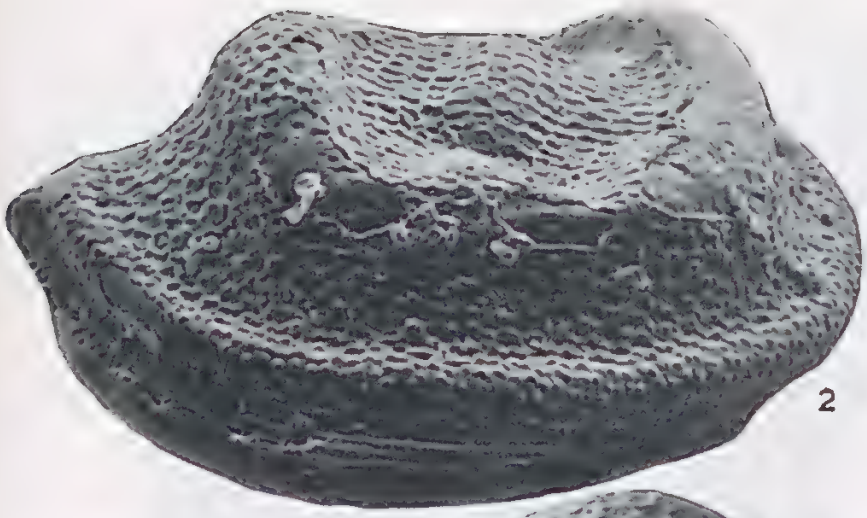
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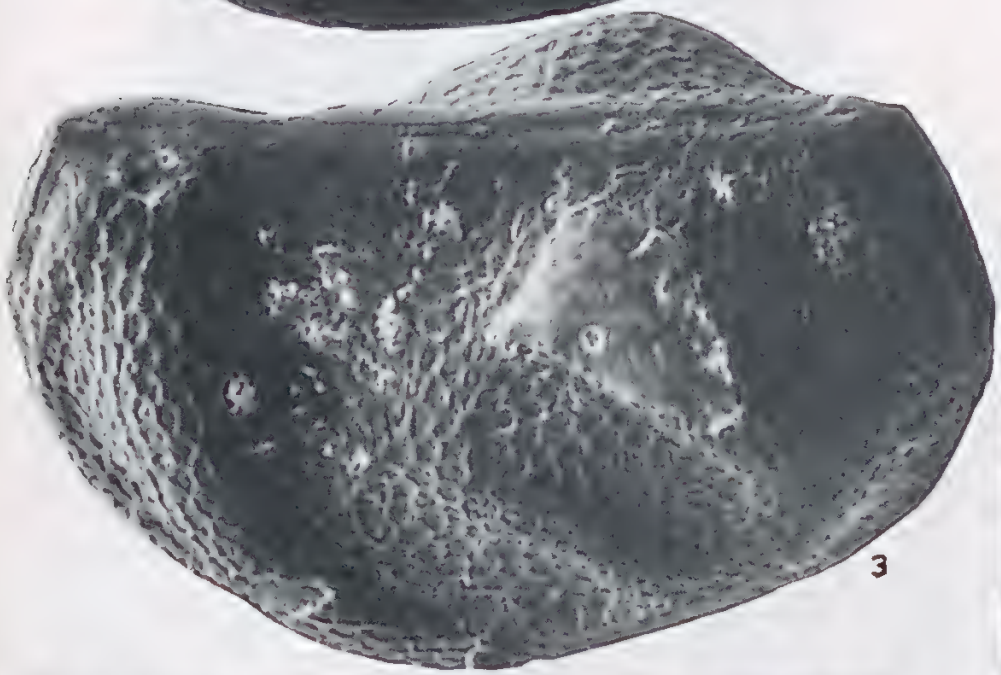
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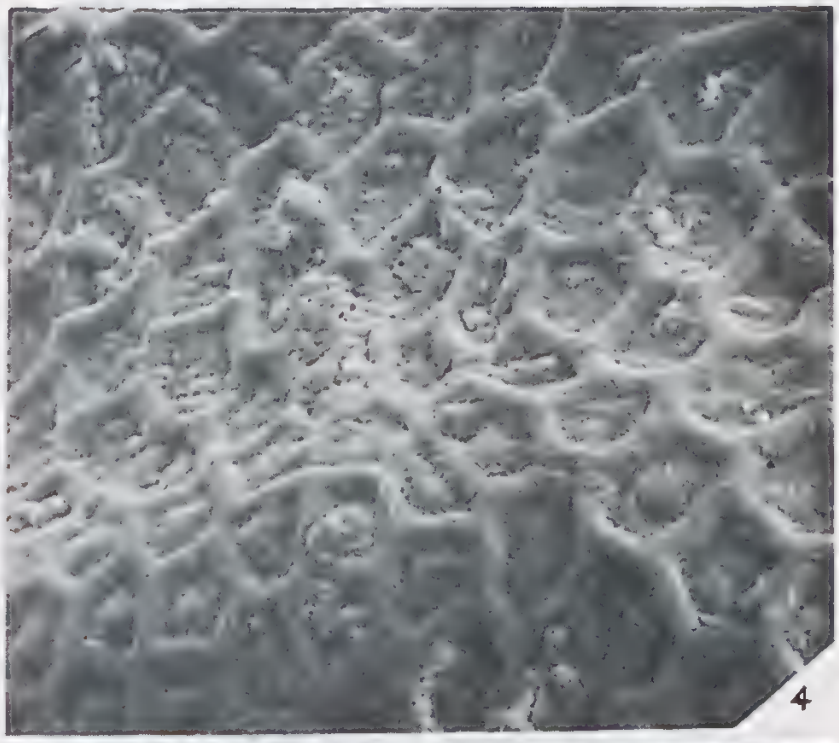
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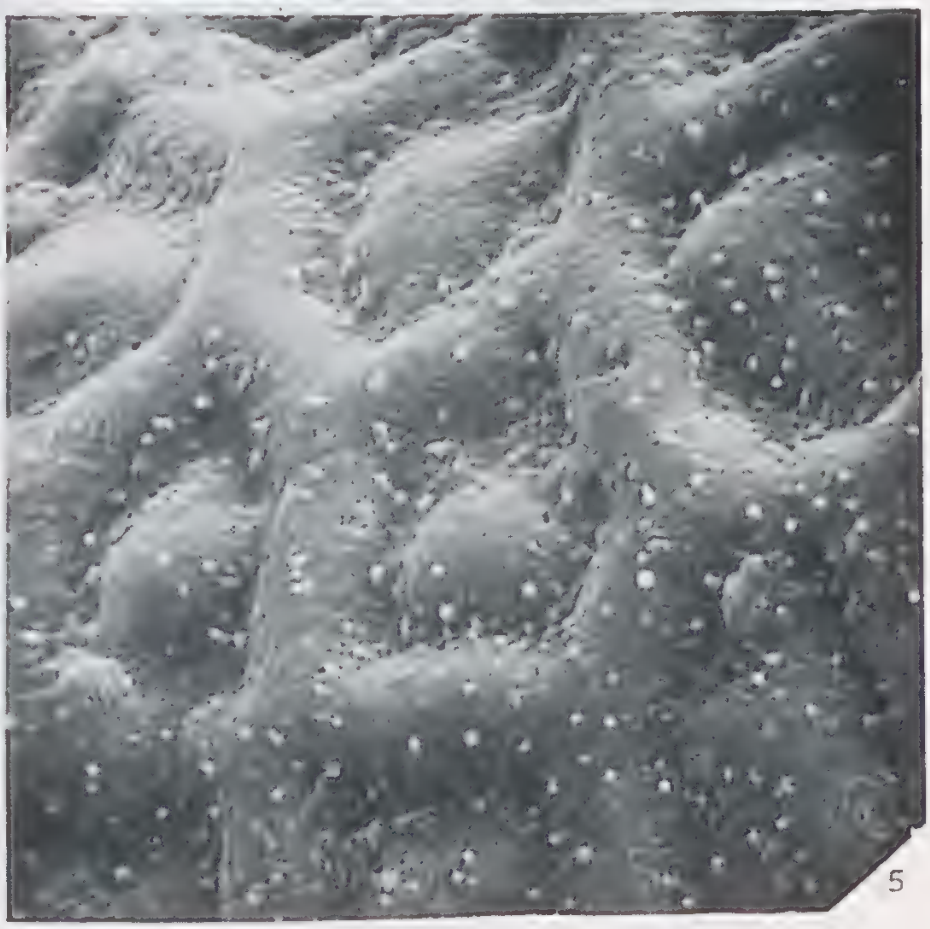
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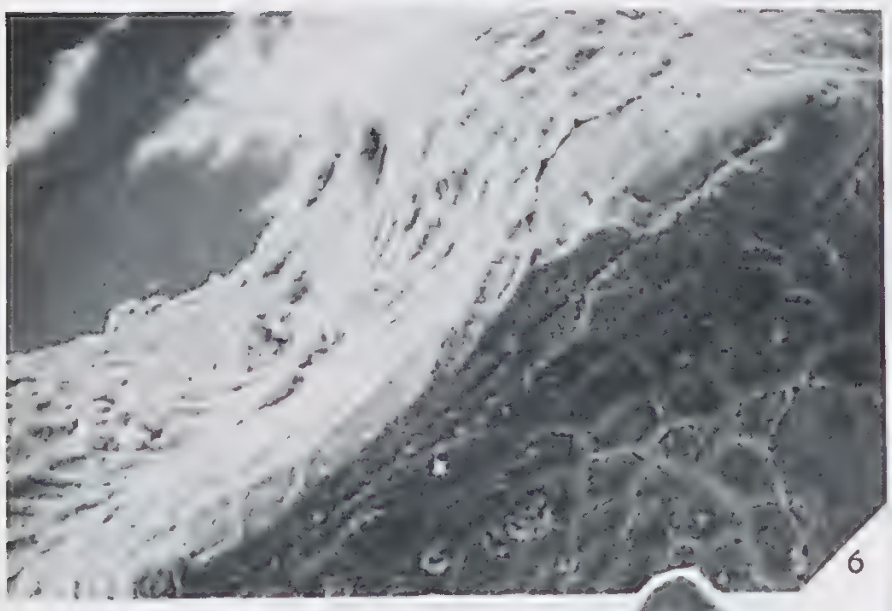
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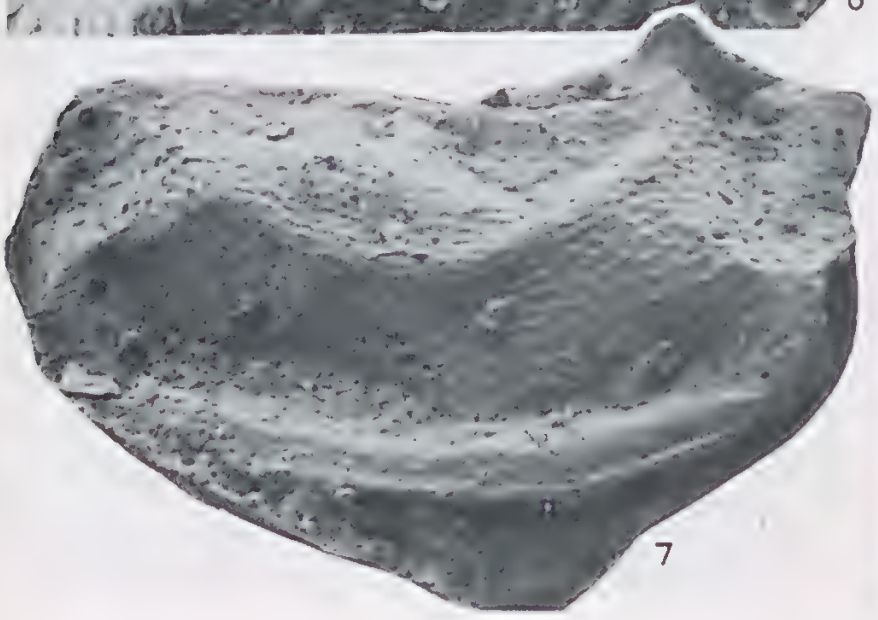
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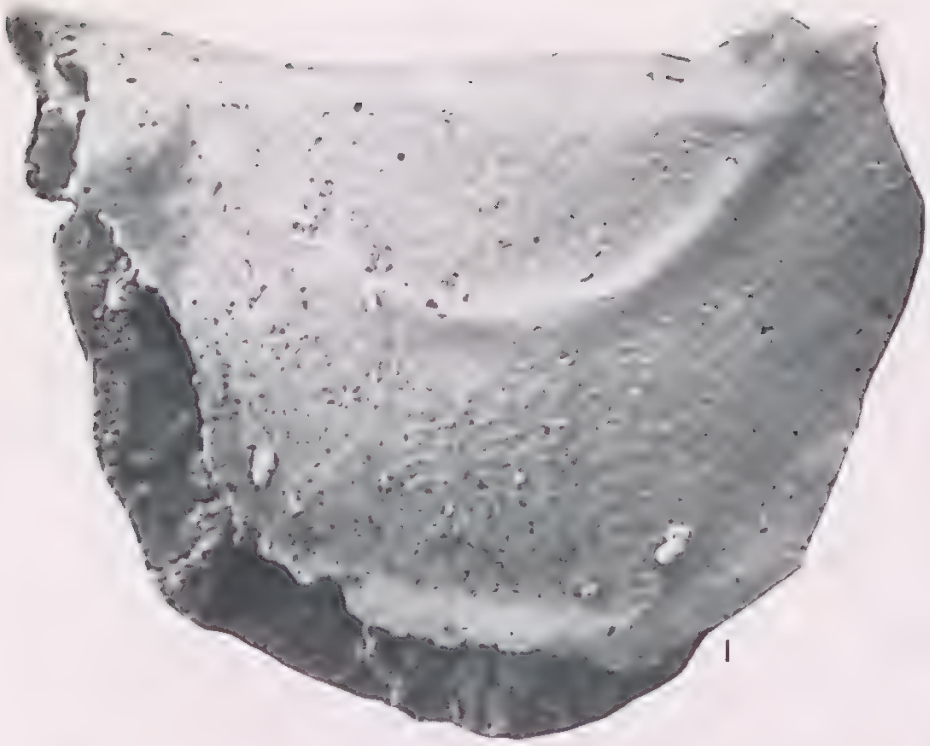
PLATE 3

EXPLANATION OF PLATE 4

(All figures scanning electron micrographs. Magnifications approximate)

1-4 *Monasterium opiki* gen. et sp. nov. **1, 2.** Right and left sides respectively of slightly broken and crushed carapaces. Second largest and second smallest instar stages respectively. 1, GSQF11985(10). Mount Murray. X 100. 2, GSQF11985(14). Mount Murray. X 110. **3.** Antero-dorsal view showing broken hollow horns. Hingeline with faint groove separating carapace halves. Anterior margins broken. GSQF11985(15). Mount Murray. X 150. **4.** Enlargement of surface of specimen of pl. 3, fig. 7. Ornament of polygonal ridges, aligned along median ridge, equidimensional on remainder of surface. Compare appearance with pl. 2, figs 9, 10, where ornament appears to be pustulose in reflected light because of low resolution optical system. X 500.

5-7 *Monasterium dorium* gen. et sp. nov. **5.** Antero-dorsal region of smallest instar stage, left side, specimen of pl. 2, fig. 15. Antero-dorsal horn complete, with ornament. X 150. **6.** Enlargement of horn of specimen of fig. 5, dorsal view. Ornament of swellings extends almost to tip, which has no ultra-smooth, apparently sensory area. Small holes possibly pore canals. X 2000. **7.** Pustulose ornament of larger specimen of pl. 2, fig. 14. X 400.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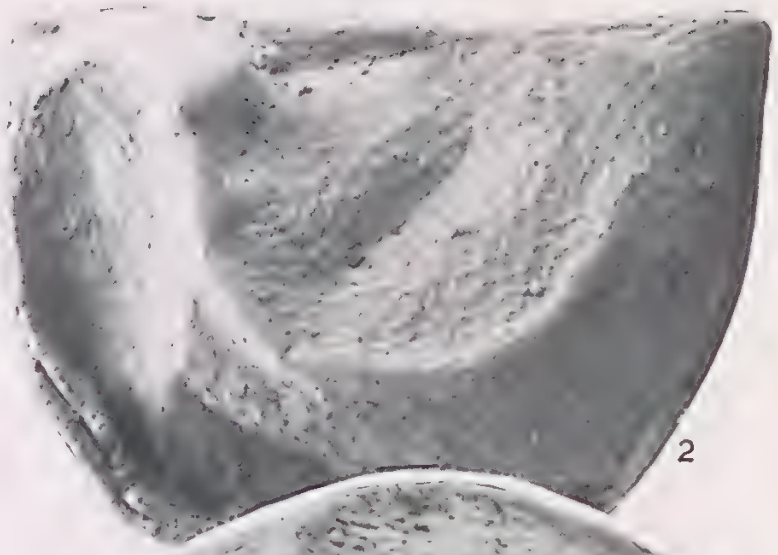
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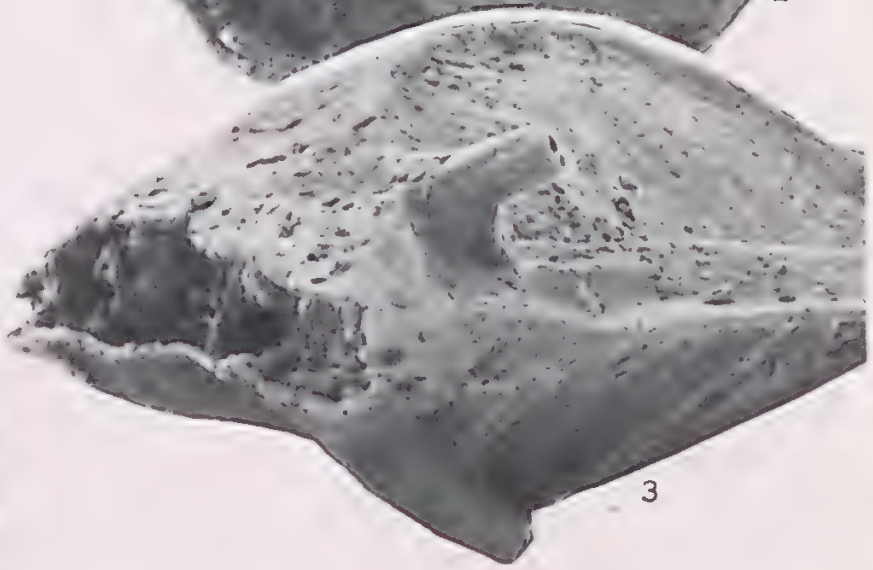
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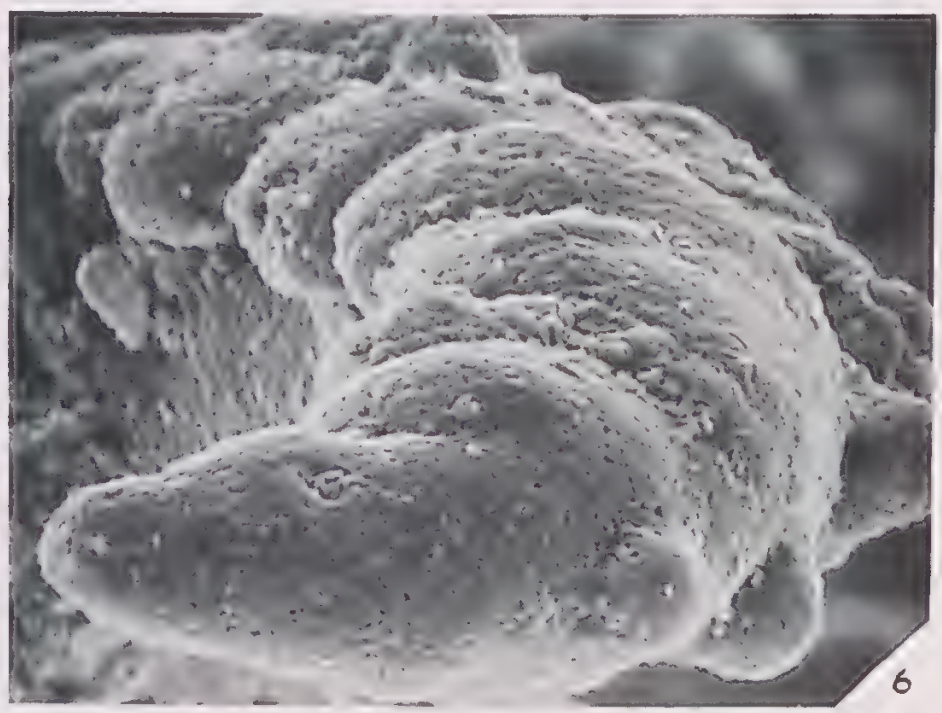
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PLATE 4

NATIONAL MUSEUM
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QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
(J. T. Woods, Chief Government Geologist)

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TRIASSIC MIOSPORES FROM THE ESK BEDS

by
N. J. de JERSEY

BRISBANE
AUGUST, 1972

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Geological Survey of Queensland

SUMMARY

Miospore assemblages are recorded from 45 samples, from the Esk Beds, at the top of the Triassic sequence of the Esk Trough, in south-eastern Queensland. The samples were derived from the cores of two exploratory wells and one stratigraphic hole, which penetrated the Esk Beds in the southern part of the trough, where they are overlain by younger sediments.

In these assemblages, 45 species are identified; additional forms are compared with described species or not formally designated. One new species, *Brachysaccus eskensis*, is proposed; additional information on the morphology and taxonomy of some other species is recorded.

The assemblages are of significantly earlier aspect than those of the Ipswich Coal Measures, including the Kholo Sub-Group, recently studied (de Jersey, 1971b). They are similar to the microflora of the upper Moolayember Formation, of the Bowen Basin, with which these sections of the Esk Beds are accordingly correlated. Elsewhere in Australia, comparisons are closest with microfloras from the Hawkesbury Sandstone and Wianamatta Group of the Sydney Basin.

The stratigraphic distribution of species common to Queensland and European microfloras is discussed; the evidence indicates a Middle Triassic age for these sections of the Esk Beds. This is in conformity with the Middle Triassic age assigned to the Moolayember Formation by de Jersey and Hamilton (1967). Assignment of this age to the Esk Beds supports the recent lithological evidence of Whitaker (1972) that they are older than the Kholo Sub-Group (at the base of the Ipswich Coal Measures), rather than previous lithological interpretations, which favoured correlation of the Esk and Kholo sequences. From the age determinations, it is concluded that movement along a major structural feature, the West Ipswich Structure, was a significant factor in the sedimentary history of the region, in Middle and Late Triassic time.

INTRODUCTION

The stratigraphy of the Esk sequence and the structural relationships of the sediments have been discussed by Hill (1960, pp. 269-274) and more recently, by Swindon (1971, pp. 107-112). These Triassic sediments (and associated volcanic rocks) are preserved in the Esk Trough (also known as the Esk Rift or the Upper Brisbane Valley Fault Trough), which is a prominent structural feature of south-eastern Queensland. It extends over a distance of 150 miles from Gayndah in the north to south of Esk; the margins of the trough are typically about 15 miles apart and trend in a north-north-west direction.

As stated by Swindon (1971, p. 107) the Esk Trough is bounded by the metamorphics and granites of the D'Aguilar Block on the east and of the Yarraman Block on the west. To the south the Triassic rocks are overlapped by the Jurassic sequence of the Moreton Basin. The oldest sediments deposited within the trough are of Permian age and are preserved in fault blocks in restricted areas. Their depositional relationship to the adjacent Triassic sections is unknown as all boundaries appear to be faulted. The Triassic rocks are much more extensive within the trough, and are up to 20,000 feet in maximum thickness. They are regarded as entirely non-marine in origin and consist of terrestrial sediments and volcanics.

Three major divisions have been recognized in the Triassic sequence. The oldest sediments, the Bryden Beds, extend along the south-eastern margin of the trough and consist mainly of interbedded conglomerate, sandstone, and andesite. They are conformably overlain by the Neara Volcanics, which are characterized by andesitic lavas, tuffs, agglomerates, and mud flows, with minor interbedded sediments. At the top of the sequence, the Esk Beds, consist dominantly of sediments (conglomerates, sandstones, and shales) with some interbedded trachytic tuffs and flows.

Plant megafossils have been collected from shale beds within each of these three units. They are of Triassic aspect, but do not provide any precise evidence on their age, within the Triassic. As the Ipswich Coal Measures, to the south-east of the Esk Trough, are also of Triassic age, various authors have discussed the relationships of the Triassic sequences in the two areas. Hill (1930, p. 186; 1960, p. 271) correlated the Esk Beds with the Kholo Sub-Group (at the base of the Ipswich Coal Measures) on the basis of lithological similarities of

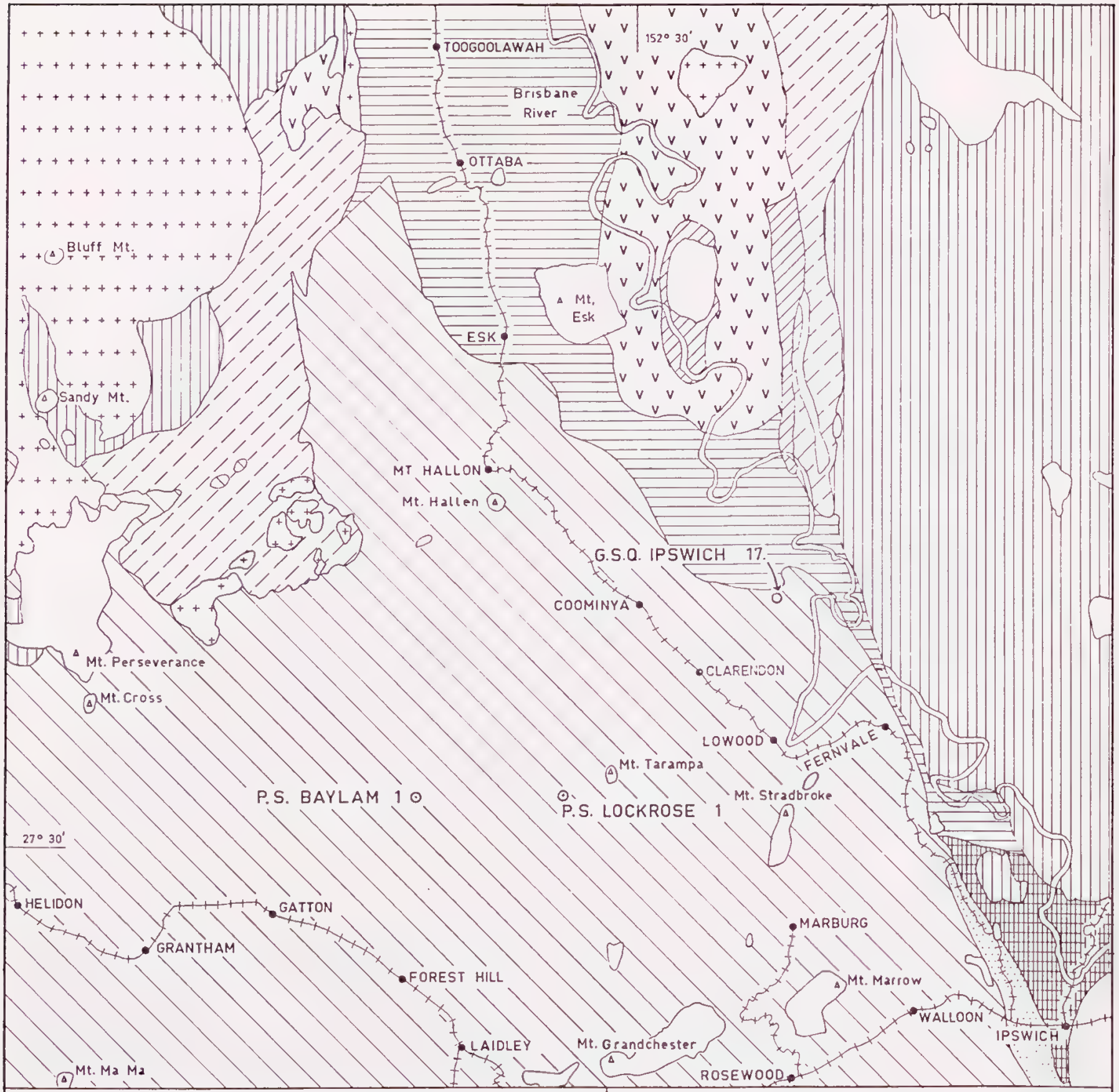

FIG. 1: LOCALITY MAP.

SHOWING LOCATIONS OF DRILL HOLES SAMPLED

SCALE

6 4 2 0 6 12 MILES

6 3 0 6 12 KILOMETRES

QUEENSLAND

LEGEND.

TERTIARY (undifferentiated)	Volcanics and sediments	
JURASSIC (undifferentiated)	Helidon Sandstone, Marburg Fmn., and Walloon Coal Measures	
TRIASSIC–JURASSIC	Bundamba Group (undifferentiated)	
TRIASSIC	Ipswich Coal Measures	
	Esk Beds	
	Neara Volcanics	V V
	Bryden Beds	
PERMIAN (undifferentiated)	Marine Sediments and Volcanics	
LOWER PALAEOZOIC	Brisbane Metamorphics and minor basic intrusions	
	Granite, granodiorite and other acid plutonic rocks	+ + + +

Geology generalized after Geological Map of the Moreton District (1955) and Whitaker (1972, fig. 2). Quaternary alluvium omitted.

conglomerates, acid tuffs, and andesitic volcanics in both sequences. This view has been quoted by Allen (1961, p. 10) and supported by Allen and Hogetoorn (1970, p. 8) and Swindon (1971). The latter author states (1971, p. 109) "The Neara Volcanics have been equated with the lower part of the Kholo Subgroup" and "It seems probable that the Esk Beds and the Bellevue Conglomerate, their lateral equivalent in the section, are to be equated with the Colleges Conglomerate (= middle portion of the Kholo Sub-group)". Recently, however, Whitaker (1972, p. 150) on the basis of the composition of derived phenoclasts in conglomerates of the Kholo Sub-Group and Bellevue Conglomerate, has regarded the latter as significantly older than the Kholo sediments.

These correlations have all been based on lithological evidence. From the palaeobotanical aspect, Jones and de Jersey (1947, pp. 74, 75) noted that while the Esk and Kholo megafloras have many species in common, there are also features in which they differ significantly. They also pointed out (1947, p. 74) that the sequences are "not laterally continuous in the field, for in the Fernvale—Fairney View area all but the Acid Tuff Stage is obscured by later sediments".

No previous account of the Esk microflora has been published. As recent studies (summarized in de Jersey, 1971b, pp. 20-22) have shown that miospore assemblages provide, in general, more precise evidence on the age and correlation of Queensland Triassic sediments, than plant megafossils, the purpose of the present investigation has been to examine evidence, from miospore assemblages, on the age and relationships of the Esk Beds. In particular a recent study of miospores from the Kholo Sub-Group (de Jersey, 1971b) has enabled detailed comparison of the Esk and Kholo assemblages, to determine whether palynological evidence supports the lithological correlations, favoured by some previous authors.

STRATIGRAPHIC DISCUSSION

The material examined came from the Esk Beds, in the southern part of the Esk Trough, where they are overlain by younger (Upper Triassic and Jurassic) sediments of the Moreton Basin. It consisted of core samples from three boreholes, comprising P.S. Lockrose 1 and P.S. Baylam 1, two exploratory wells drilled in 1965 by the Phillips Petroleum Company and G.S.Q. Ipswich 17, drilled in 1970 as part of the stratigraphic drilling programme of the Geological Survey of Queensland. For locations of these holes, reference should be made to the locality map (Figure 1).

As G.S.Q. Ipswich 17 was continuously cored through a vertical thickness of over 2200 feet of Esk Beds, it has provided the most complete record of these sediments of the three holes. It penetrated Helidon Sandstone down to a depth of 696 feet, where it is underlain by the Raceview Formation. Below the latter unit, from a depth of 752 feet, the Esk Beds extend to total depth (2956 feet 8 inches). These formation boundaries, together with lithologic data on the section penetrated, have been supplied by R. J. Allen (pers. comm.); they are derived from an unpublished lithologic log prepared by I. J. Reeve of the Petroleum Section, Geological Survey of Queensland. This log indicates that the stratigraphic thickness of Esk Beds penetrated is somewhat less than the vertical thickness of about 2200 feet, as while core from about two-thirds of this thickness shows relatively gentle dips (less than ten degrees) the remainder represents more steeply dipping strata. The lithologic log shows an alternation of conglomerate beds with finer sediments (sandstone, siltstone, and shale) for most of this thickness. Thin coal seams are present in the lower part of the section, between the depths of 2750 feet and 2850 feet. Beds of tuff were recorded in three sections, between 1490 and 1520 feet, between 2230 and 2250 feet, and between 2280 and 2290 feet.

From the shale beds within this Esk succession, 23 core samples (each from 1 to 2 inches in vertical thickness) have been selected and processed; their depths, lithologies, and miospore assemblages are recorded in the Appendix of this paper. Assemblages from three other samples, one from the Raceview Formation, and two from the Helidon Sandstone, are also recorded.

Of the two exploratory wells, P.S. Baylam 1 yielded the greater number of samples for study. It penetrated Jurassic sediments to a depth of 1126 feet (Patterson, 1966b); below this level a thin section of sediments containing a Raceview-type assemblage (at 1136 feet—see Appendix) was encountered. The Raceview—Esk boundary appears to be located at about 1240 feet. The Esk Beds in this well extend down to a depth of 2547 feet; they consist of beds of conglomerate, sandstone, siltstone, and shale, which are generally similar in lithology to the section of this unit penetrated in G.S.Q. Ipswich 17. Two conventional cores and fourteen sidewall cores gave significant yields of miospores; their depths, lithologies, and miospore assemblages are recorded in the Appendix of this paper. Below the Esk Beds, the sections from 2547 to 2730 feet (brecciated limestone, sandstone, and shale) and from 2730 feet to total depth of 3946 feet (limestone, shale, sandstone, siltstone, and tuff) are recorded respectively as probably Permian and probably pre-Permian (Patterson, 1966b).

Finally, assemblages are recorded from six shale samples from P.S. Lockrose 1, all from conventional cores and with depths ranging from 2205 to 4004 feet. From the surface this well penetrated Quaternary sediments to a depth of 220 feet; these were underlain by Jurassic strata down to a level of 1827 feet (Patterson, 1966a). Triassic sediments of the Esk Beds were present between this depth and 4862 feet; their lithologic composition appears to show a general similarity to the Esk sequences in G.S.Q. Ipswich 17 and P.S. Baylam 1. From the latter depth to total depth of 5497 feet an older section, regarded as probably Permian (Patterson, 1966a) was penetrated. It consisted of silicified limestone, shale, sandstone, rhyolite, trachyte, and tuff; there is a distinct lithological difference from the overlying Triassic strata. A sample of shale from a depth of 5000 feet 6 inches, from Core 15, within this interval was processed, but yielded no recognizable microfossils, the maceration residue consisting largely of highly carbonized plant material. If the pre-Triassic age suggested for this lower section is accepted, the Triassic interval is about 3000 feet in thickness in this well, and is the thickest section of Esk Beds in the three holes studied.

PROCESSING OF SAMPLES

Conventional methods were used in laboratory treatment of the samples. The procedure (with hydrofluoric and hydrochloric acids) was similar to that recorded in a recent paper (de Jersey, 1971a, p. 3). Oxidation, when necessary, was confined to brief periods of treatment (up to three or four minutes) with concentrated nitric acid; in many samples the maceration residues required no oxidation. Zinc bromide solution was used throughout in specific gravity separation of miospore-rich material from opaque carbonaceous matter and undissolved mineral residue. The maceration residues were mounted on microslides in "White Xam", a balsam-type mounting medium.

The quality of preservation of the Esk miospores was rather variable, from one sample to another and even within the material of one assemblage. There appeared to be no general pattern in the quality of preservation, except that the assemblages from G.S.Q. Ipswich 17 tended to be better preserved than those from the two exploratory wells. This was to be expected, as the continuous coring of the former enabled more suitable samples to be selected for processing. There was also a trend, apparently independent of quality of preservation, for the deeper assemblages to contain darker, more carbonized miospores.

As stated previously, figured specimens are located by the stage co-ordinates of a Carl Zeiss GFL Microscope. The reference point quoted for each microslide in the text refers to the lower right hand corner of the cover glass, when the slide is inserted with the label to the observer's left hand side. Microslides prepared during the investigation are housed in the collection of the Palynology Section and the samples themselves are housed in the Core Library of the Geological Survey.

SYSTEMATIC DESCRIPTIONS

The arrangement of genera, in this section, is based on the classification of Potonié (1970).

Anteturma PROXIMEGERMINANTES Potonié, 1970

Turma TRILETES Reinsch emend. Dettmann, 1963

Subturma AZONOTRILETES Luber emend. Dettmann, 1963

Infraturma LAEVIGATI Bennie & Kidston emend. Potonié, 1956

Genus BIRETISPORITES Delcourt & Sprumont emend. Delcourt, Dettmann & Hughes, 1963

Type species: Biretisporites potoniaei Delcourt & Sprumont, 1955.

Biretisporites sp. A
Plate 1, Figure 1

Figured specimen: Slide S3257, stage co-ordinates 10.1, 89.8; diameter 30 μ. Co-ordinates of reference point 26.0, 85.0.

Locality: G.S.Q. Ipswich 17, 1863 feet 2 inches.

Remarks: Three specimens, including the specimen figured, are regarded as conspecific with specimens from the Rewan Formation recorded as *Biretisporites* sp. A (de Jersey, 1970a, p. 4; pl. 1, fig. 1). Insufficient specimens are available for formal specific designation.

Distribution: Rewan Formation (de Jersey, 1970a); Esk Beds (this paper).

Genus CALAMOSPORA Schopf, Wilson & Bentall, 1944

Type species: Calamospora hartungiana Schopf, in Schopf, Wilson & Bentall, 1944.

Calamospora tener (Leschik) de Jersey, 1962
Plate 1, Figure 2

Figured specimen: Slide S3211, stage co-ordinates 19.0, 89.7; diameter 41 μ. Co-ordinates of reference point 26.9, 83.4.

Locality: G.S.Q. Ipswich 17, 1203 feet 9 inches.

Distribution: Recorded in Triassic and Jurassic assemblages from Europe and Great Britain. Queensland records: Triassic of Tivoli and Blackstone Formations, Ipswich Coal Measures (de Jersey, 1962, 1970b, 1971b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Jurassic of Marburg Formation (de Jersey, 1971a); Triassic of Esk Beds (this paper).

Genus DICTYOPHYLLIDITES Couper emend. Dettmann, 1963

Type species: Dictyophyllidites harrisii Couper, 1958.

Dictyophyllidites harrisii Couper, 1958

Remarks: This species is recorded in only one assemblage, in the material studied.

Distribution: For previous records see de Jersey (1971a, p. 4).

Dictyophyllidites mortoni (de Jersey) Playford & Dettmann, 1963

Remarks: This relatively long-ranged species is widespread in the Esk assemblages.

Distribution: For previous Queensland records see de Jersey (1971b, p. 4).

Genus LEIOTRILETES (Naumova) Potonié & Kremp, 1954

Type species: Leiotriletes sphaerotriangulus (Loose) Potonié & Kremp, 1954.

Leiotriletes directus Balme & Hennelly, 1956

Remarks: Spores of this simple, generalized species are widely distributed in the Esk assemblages, as in other microfloras from the Lower Mesozoic of Queensland.

Genus PUNCTATISPORITES Ibrahim emend. Potonié & Kremp, 1954

Type species: Punctatisporites punctatus Ibrahim, 1933.

Punctatisporites fungosus Balme, 1963
Plate 1, Figure 10

Figured specimen: Slide S3550, stage co-ordinates 14.2, 84.1; diameter 84 μ. Co-ordinates of reference point 26.8, 83.1.

Locality: P.S. Baylam 1, sidewall core 3, 2197 feet.

Remarks: The figured specimen is representative of three specimens in one preparation, which conform in all significant diagnostic features, to the type population of this species (Balme, 1963, p. 16, pl. 4, figs. 10, 11). Balme (1970, p. 321) regards the distinguishing features of *P. fungosus* as being "its laesurae of unequal length and fairly thick, faintly structured exine."

Distribution: Lower Triassic Kockatea Shale (Perth Basin) and Blina Shale (Canning Basin) of Western Australia (Balme, 1963); Lower Triassic Mianwali Formation, Salt Range, Pakistan (Balme, 1970); Esk Beds (this paper).

Genus RETUSOTRILETES Naumova emend. Streel, 1964

Type species: Retusotriletes simplex Naumova, 1953.

Retusotriletes junior de Jersey & Hamilton, 1967

Remarks: This species is recorded from two samples, from near the base of the Esk section penetrated in G.S.Q. Ipswich 17.

Distribution: Lower and middle Moolayember Formation (de Jersey and Hamilton, 1967); Clematis Sandstone (de Jersey, 1968); Esk Beds (this paper).

Infraturma APICULATI Bennie & Kidston emend. Potonié, 1965

Subinfraturma VERRUCATI Dybová & Jachowicz, 1957

Genus CLAVATISPORITES Kedves & Simoncsics, 1964

Type species: Clavatisporites clavus Kedves & Simoncsics, 1964.

Remarks: Potonié (1970, p. 18) and the writer (de Jersey, 1971b, p. 5) have independently placed *Clavatriletes* Herbst, 1965 in synonymy with this genus.

Clavatisporites sp. cf. *C. hammenii* (Herbst) de Jersey, 1971

Plate 1, Figure 3

Figured specimen: Slide S3183, stage co-ordinates 14.8, 97.5; diameter 50 μ. Co-ordinates of reference point 25.9, 84.7.

Locality: G.S.Q. Ipswich 17, 876 feet 5 inches.

Distribution of Clavatisporites hammenii: Upper Triassic Los Rastros Formation, Argentina (Herbst, 1965).

Distribution of Clavatisporites *sp. cf.* hammenii: Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1970b, 1971b); Triassic of Narrabeen Group, Hawkesbury Sandstone, Wianamatta Group of Sydney Basin (Helby, in press); Esk Beds (this paper).

Genus CONVERRUCOSISPORITES Potonié & Kremp, 1954

Type species: Converrucosisporites triquetrus (Ibrahim) Potonié & Kremp, 1954.

Converrucosisporites cameroni (de Jersey) Playford & Dettmann, 1965

Plate 1, Figure 7

Figured specimen: Slide S3425, stage co-ordinates 15.5, 97.7; diameter 44 μ. Co-ordinates of reference point 26.4, 80.5.

Locality: P.S. Lockrose 1, Core 11, 4004 feet.

Distribution: Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1962, 1964, 1970b, 1971a, 1971b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Tarong Beds (de Jersey, 1970c); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic and Jurassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Triassic of Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press); Esk Beds (this paper).

Genus GUTTATISPORITES Visscher, 1966

Type species: Guttatisporites guttatus Visscher, 1966.

Remarks: Potonié (1970, p. 21) regarded this genus as close to *Schopfites* Kosanke, 1950, although he did not formally place it in synonymy with the latter. However it is considered that *Guttatisporites* can be maintained as a separate genus, as the two species of *Schopfites* described by Kosanke (1950, pp. 52, 53), although they exhibit closely packed distal projections, do not appear to have the compound elements characteristic of *Guttatisporites.* In addition, their proximal surfaces are largely smooth, in contrast to the comprehensive sculpture of *G. guttatus.*

Guttatisporites visscheri de Jersey, 1968

Remarks: This species occurs sporadically in assemblages from G.S.Q. Ipswich 17, P.S. Baylam 1, and P.S. Lockrose 1.

Distribution: Lower Moolayember Formation, Clematis Sandstone (de Jersey, 1968); Upper Rewan Formation (de Jersey, 1971a); Esk Beds (this paper).

Genus UVAESPORITES Döring emend. Helby, in de Jersey, 1971

Type species: Uvaesporites glomeratus Döring, 1965.

Uvaesporites verrucosus (de Jersey) Helby, in de Jersey, 1971

Plate 1, Figure 5

Figured specimen: Slide S3306, stage co-ordinates 12.5, 89.8; diameter 35 μ. Co-ordinates of reference point 27.3, 81.4.

Locality: G.S.Q. Ipswich 17, 2631 feet.

Remarks: In the specimen figured, separation of the exine layers is visible in the upper part of the illustration.

Distribution: Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1964, 1970b, 1971a, 1971b): Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Hawkesbury Sandstone and Wianamatta Group, Sydney Basin (Helby, in press); Triassic of Esk Beds (this paper); Jurassic of Precipice Sandstone, Evergreen Formation, lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969);

Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971a).

Subinfraturma NODATI Dybová & Jachowicz, 1957

Genus APICULATISPORIS Potonié & Kremp, 1956

Type species: Apiculatisporis aculeatus (Ibrahim) Potonié, 1956.

Apiculatisporis clematisi de Jersey, 1968
Plate 1, Figure 4

Figured specimen: Slide S3395, stage co-ordinates 15.4, 88.1; diameter 36 μ. Co-ordinates of reference point 27.0, 83.0.

Locality: P.S. Lockrose 1, Core 5, 2205 feet.

Remarks: The specimen figured illustrates the simple laesurae and the variation in the sculptural elements which, although mainly conate, have apices ranging from broadly rounded to sharply pointed. By these features the species can be distinguished from *Apiculatisporis globosus* (Leschik) Playford & Dettmann, 1965, which, as previously indicated (de Jersey, 1971b, p. 7), is characterized by lipped laesurae and has sculptural elements which are more uniform in size and shape and which tend to be more elongate than those of *A. clematisi.*

Distribution: Clematis Sandstone (de Jersey, 1968); Esk Beds (this paper).

Genus CADARGASPORITES de Jersey & Paten emend. Reiser & Williams, 1969

Type species: Cadargasporites baculatus de Jersey & Paten emend. Reiser & Williams, 1969.

Cadargasporites sp.
Plate 1, Figure 6

Figured specimen: Slide S3281, stage co-ordinates 14.2, 84.6; diameter 50 μ. Co-ordinates of reference point 26.0, 82.8.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Remarks: The specimen figured is two-layered and is characterized by fine granulate-conate sculpture and prominent lips. The sculptural elements are much finer than in the other species described from the Late Triassic and Early Jurassic of Queensland (*C. baculatus* de Jersey & Paten emend. Reiser & Williams, *C. granulatus* de Jersey & Paten emend. Reiser & Williams, and *C. reticulatus* de Jersey & Paten). *C. senectus* de Jersey & Hamilton, from the Moolayember Formation (Middle Triassic) differs in having micro-rugulate to micro-reticulate sculpture. A species which has a somewhat similar sculptural pattern is *C. wattsae* Helby (in press), from the Narrabeen Group of the Sydney Basin, but the Esk specimen lacks the apical bosses at the ends of laesurae in the latter species and also has conate, as well as granulate, sculptural elements. It is the only specimen of *Cadargasporites* observed in the present study.

Genus LOPHOTRILETES Naumova emend. Potonié & Kremp, 1954

Type species: Lophotriletes gibbosus (Ibrahim) Potonié & Kremp, 1954.

Lophotriletes novicus Singh, 1964
Plate 1, Figure 9

Figured specimen: Slide S3252, stage co-ordinates 20.5, 93.8; diameter 44 μ. Co-ordinates of reference point 27.1, 84.0.

Locality: G.S.Q. Ipswich 17, 1588 feet 11 inches.

Remarks: Helby (in press) regards *Lophotriletes bauhiniae* de Jersey & Hamilton, from the Moolayember Formation (de Jersey and Hamilton, 1967, pp. 7, 8), as a junior synonym of *L. novicus.* Apart from its larger size, the former species is similar to *L. novicus* in all other features. As Balme (1970, p. 324) has recently extended the size range of *L. novicus* to the lower limit of the size range of *L. bauhiniae*, there is evidently continuous size gradation in spores of this morphological group and accordingly Helby's conclusions on synonymy of the species are accepted. Balme (1970, p. 324) has pointed out the difficulties involved in specific subdivision of spores grouped in this section of *Lophotriletes*; in view of the gradation evident in diagnostic characters broad specific divisions appear desirable.

Distribution: Late Permian Chia Zairi Formation of northern Iraq (Singh, 1964); Early Permian Amb Formation, Late Permian Wargal Limestone and Chhidru Formation of the Salt Range, Pakistan (Balme, 1970); Middle Triassic of lower Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, upper Rewan Formation (de Jersey, 1968, 1970a); Triassic of Esk Beds (this paper); Triassic of Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press).

Genus OSMUNDACIDITES Couper, 1953

Type species: Osmundacidites wellmanii Couper, 1953.

Osmundacidites spp.

Remarks: Specific identification of specimens assigned to *Osmundacidites* has not been attempted. Species of this genus appear to be relatively long-ranged, within the Triassic of Queensland.

Subinfraturma BACULATI Dybová & Jachowicz, 1957

Genus BACULATISPORITES Thomson & Pflug, 1953

Type species: Baculatisporites primarius (Wolff) Thomson & Pflug, 1953.

Baculatisporites sp. cf. *B. comaumensis* (Cookson) Potonié, 1956
Plate 1, Figure 8

Figured specimen: Slide S3256, stage co-ordinates 11.4, 93.1; diameter 40 μ. Co-ordinates of reference point 27.7, 84.0.

Locality: G.S.Q. Ipswich 17, 1863 feet 2 inches.

Remarks: The figured specimen has some conate, as well as baculate elements and is accordingly compared, rather than identified, with Cookson's species.

Genus NEORAISTRICKIA Potonié, 1956

Type species: Neoraistrickia truncata (Cookson) Potonié, 1956.

Remarks: Potonié (1970, p. 27) discusses the taxonomy of *Neoraistrickia*, which Schulz (1967, p. 563) regards as a junior synonym of *Cepulina* Malyavkina, 1949. As originally proposed, the latter genus was broadly defined and would include forms assigned to the genera *Acanthotriletes*, *Apiculatisporis*, *Lophotriletes*, *Neoraistrickia*, and *Raistrickia* (Potonié, 1960, p. 44). Schulz (1967, p. 563) has restricted the concept of *Cepulina* around *C. bacculifera* Malyavkina, 1949, which he has selected as type species. Before a final decision is made on the circumscription of this genus, re-examination of Malyavkina's material seems desirable, as Potonié (1970, p. 27) mentions features regarded as characteristic by Schulz, but not evident from the description and figures of the Russian author. Until such re-examination is carried out, the writer prefers to retain *Neoraistrickia* Potonié, 1956 as a repository for the species *N. taylorii* Playford and Dettmann, 1965, recorded below.

Neoraistrickia taylorii Playford & Dettmann, 1965

Plate 1, Figure 11

Figured specimen: Slide S3425, stage co-ordinates 20.1, 81.2; diameter (excluding projections) 44 μ. Co-ordinates of reference point 26.4, 80.5.

Locality: P.S. Lockrose 1, Core 11, 4004 feet.

Distribution: Triassic of Ipswich Coal Measures, lower Bundamba Group (Hill, Playford and Woods, 1965; de Jersey 1970b, 1971b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Tarong Beds (de Jersey, 1970c); Triassic and Jurassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Late Triassic of Tasmania (Playford, 1965); Triassic of Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of New South Wales (Helby, in press); Triassic of Esk Beds (this paper); Jurassic of Precipice Sandstone, Evergreen Formation and lower Hutton Sandstone of Surat Basin (Reiser and Williams, 1969); Jurassic of Helidon Sandstone, Marburg Formation (de Jersey, 1971a).

Infraturma MURORNATI Potonié & Kremp, 1954

Genus DUPLEXISPORITES Deák emend. Playford & Dettmann, 1965

Type species: Duplexisporites generalis Deák, 1962.

Duplexisporites problematicus (Couper) Playford & Dettmann, 1965

Plate 3, Figures 1 and 2

Figured specimen (*Plate 3, Figure 1*): Slide S3486, stage co-ordinates 7.0, 87.2; diameter 46 μ. Co-ordinates of reference point 26.0, 82.5.

Locality: P.S. Baylam 1, sidewall core 9, 1362 feet.

Figured specimen (*Plate 3, Figure 2*): Slide S3572, stage co-ordinates 14.8, 94.5; diameter 50 μ. Co-ordinates of reference point 26.2, 85.0.

Locality: G.S.Q. Ipswich 17, 2885 feet 3 inches.

Remarks: The morphology and synonymy of this species have been discussed by Helby (in press) and the writer (de Jersey, 1970b, p. 8). It extends throughout the Esk sequence in G.S.Q. Ipswich 17, from the uppermost sample examined (813 feet 3 inches) down to the lowest sample which gave a good yield of spores and pollen (2885 feet 3 inches). It is also recorded in assemblages from P.S. Baylam 1 and P.S. Lockrose 1.

Distribution: Widely distributed in Triassic and Jurassic microfloras. For previous Queensland records see de Jersey (1971b, p. 8).

Genus FOVEOSPORITES Balme, 1957

Type species: Foveosporites canalis Balme, 1957.

Foveosporites mimosae de Jersey and Hamilton, 1967

Distribution: Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Esk Beds (this paper).

Genus RUGULATISPORITES Pflug, in Thomson & Pflug, 1953

Type species: Rugulatisporites quintus Thomson & Pflug, 1953.

Rugulatisporites trisinus de Jersey & Hamilton, 1967

Plate 2, Figure 12

Figured specimen: Slide S3261, stage co-ordinates 11.2, 90.8; diameter 48 μ. Co-ordinates of reference point 26.9, 82.0.

Locality: G.S.Q. Ipswich 17, 1661 feet 2 inches.

Remarks: Only two specimens of this species have been observed in the Esk assemblages.

Distribution: Middle Triassic of lower Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of upper Clematis Sandstone (de Jersey, 1968); Esk Beds (this paper).

Turma ZONALES Bennie & Kidston emend. Potonié, 1956

Subturma AURITOTRILETES Potonié & Kremp, 1954

Infraturma AURICULATI Schopf emend. Dettmann, 1963

Genus INDOSPORA Bharadwaj emend. de Jersey, 1968

Type species: Indospora clara Bharadwaj, 1962.

Indospora clara Bharadwaj, 1962

Plate 2, Figure 10

Figured specimen: Slide S3183, stage co-ordinates 8.9, 88.2; diameter 51 μ. Co-ordinates of reference point 25.9, 84.8.

Locality: G.S.Q. Ipswich 17, 876 feet 5 inches.

Remarks: I. clara is a rare component of the Esk assemblages.

Distribution: Upper Permian of Raniganj Coalfield, India (Bharadwaj, 1962); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Upper Permian of Chhidru Formation, Salt Range, Pakistan (Balme, 1970); Upper Permian of Wagina Sandstone, Perth Basin, Western Australia (Balme, 1970); Triassic of Esk Beds (this paper). Helby (in press) records the species (which he interprets broadly, to include *I. reticulata* de Jersey, 1968) from the Narrabeen Group, Hawkesbury Sandstone, and Wianamatta Group of the Sydney Basin.

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI Potonié & Klaus emend. Dettmann, 1963

Genus DENSOISPORITES Weyland & Krieger emend. Dettmann, 1963

Type species: Densoisporites velatus Weyland & Krieger emend. Krasnova, 1961.

Densoisporites sp. cf. *D. playfordi* (Balme) Dettmann, 1963

Plate 2, Figure 8

Figured specimen: Slide S3257, stage co-ordinates 22.7, 96.4; diameter 31 μ. Co-ordinates of reference point 26.0, 85.0.

Locality: G.S.Q. Ipswich 17, 1863 feet 2 inches.

Remarks: The specimen figured conforms to Balme's description of *D. playfordi* (Balme, 1963; 1970, p. 339) in most features, except that its overall diameter is appreciably less and the ratio of the diameter of the intexine to that of the exoexine appreciably greater, than in the type population of the species. As it is the only such specimen found in the Esk assemblages, it is compared, rather than identified, with *D. playfordi.*

Distribution of D. playfordi: Early and (?Middle) Triassic of Western Australia (Balme, 1963); Ross Formation (Early Triassic) of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Chhidru Formation (Late Permian) and Mianwali Formation (Early Triassic) of Salt Range, Pakistan (Balme, 1970); Narrabeen Group of Sydney Basin (Helby, in press).

Genus DENSOSPORITES Berry emend. Butterworth, Jansonius, Smith & Staplin, 1964

Type species: Densosporites covensis Berry, 1937.

Densosporites raceviewensis de Jersey, 1971

Plate 2, Figure 7

Figured specimen: Slide S3259, stage co-ordinates 11.0, 85.8; diameter 28 μ. Co-ordinates of reference point 27.9, 83.2.

Locality: G.S.Q. Ipswich 17, 1661 feet 2 inches.

Remarks: The specimen figured exhibits characteristic features of this species, such as the convexly subtriangular amb, interradial broadening of the cingulum and thin intexine.

Distribution: Raceview Formation (de Jersey, 1970b, 1971a); Ipswich Coal Measures (de Jersey, 1971b); Esk Beds (this paper).

Genus KRAEUSELISPORITES Leschik emend. Jansonius, 1962

Type species: Kraeuselisporites dentatus Leschik, 1955.

Kraeuselisporites saeptatus Balme, 1963

Remarks: One specimen, identifiable with this species, has been observed in the Esk material.

Distribution: Early Triassic of Kockatea Shale and Blina Shale, Western Australia (Balme, 1963); Early Triassic of Rewan Formation (de Jersey, 1970a); Triassic of Esk Beds (this paper).

Kraeuselisporites verrucifer de Jersey & Hamilton, 1967

Remarks: Concerning the relationship of this species to *K. differens* Helby (Helby, 1967, p. 65) the writer stated (de Jersey, 1968, p. 10) that the latter species differed from *K. verrucifer* "in exhibiting distinct thickening at the base of the zona, with which is associated closer spacing of the sculptural elements. However, in view of the relative rarity of *Kraeuselisporites* in the Clematis and Moolayember assemblages, which have been examined, insufficient specimens are available to explore fully any possibility of a gradation between them in these features." Helby (in press) regards the darkening of the base of the zona, and associated crowding of the sculptural elements, in *K. differens*, as a compression feature, not a primary feature, and believes that the two species are synonymous.

In the Queensland material, sufficient data are not yet available to decide between these two interpretations. Only one specimen has been observed in the Esk assemblages; it is similar to the Moolayember specimens (de Jersey and Hamilton, 1967, p. 11; pl. 6, figs. 1, 2, 5, and 6) and does not exhibit closer spacing of the equatorial elements towards the base of the zona, to any significant extent.

Distribution: Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Esk Beds (this paper).

Genus NEVESISPORITES de Jersey & Paten, 1964

Type species: Nevesisporites vallatus de Jersey & Paten, 1964.

Nevesisporites limatulus Playford, 1965

Remarks: Only two specimens of this species have been observed in the Esk assemblages.

Distribution: Triassic of Tiers Formation, Tasmania (Playford, 1965); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press); Esk Beds (this paper).

Infraturma ZONATI Potonié & Kremp, 1954

Subinfraturma PROMONOSACCITI Potonié, 1970

Genus GUTHOERLISPORITES Bharadwaj, 1954

Type species: Guthoerlisporites magnificus Bharadwaj, 1954.

Guthoerlisporites cancellosus Playford & Dettmann, 1965

Remarks: This species is long-ranged (within the Triassic). It is a rare component of the Esk assemblages.

Distribution: Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965);

Triassic of Tasmania (Playford, 1965); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Ipswich Coal Measures, lower Bundamba Group (Hill, Playford and Woods, 1965; de Jersey, 1970b, 1971b); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Narrabeen Group, Hawkesbury Sandstone, and Wianamatta Group of Sydney Basin (Helby, in press); Esk Beds (this paper).

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma SCULPTATOMONOLETI Dybová & Jachowicz, 1957

Genus ARATRISPORITES Leschik emend. Playford & Dettmann, 1965

Type species: Aratrisporites parvispinosus Leschik emend. Playford, 1965.

Remarks: Concerning differentiation of species within this genus, Balme has pointed out (1970, p. 352) "About twenty species of *Aratrisporites* have now been described, distinguished from one another on the basis of size and sculptural patterns. Some of these may prove difficult to maintain as further data accumulate, for, as Helby and Martin (1965) have noted, the sculptural patterns of *Aratrisporites* appear to be easily affected by preservational differences". As indicated below, the occurrence of specimens in the Esk assemblages, suggestive of a gradation between *A. paenulatus* and *A. strigosus*, lends some support to the view that further data may lead to regrouping of specific taxa in this genus. Nevertheless, in any appraisal of the limits of specific groups, a conservative approach seems desirable, to avoid the loss of data of potential biostratigraphic value. A good example of a taxon which is significant from the biostratigraphic aspect is *A. flexibilis* Playford & Dettman, 1965. Spores of this species, characterized by large baculate or subbaculate sculptural elements, prominent lips and a relatively large, thin inner layer, are present in the Late Triassic Ipswich Coal Measures and Leigh Creek Coal Measures, but have not been observed in older assemblages from the Bowen Basin, nor in those of the Esk Beds.

Aratrisporites banksi Playford, 1965

Plate 2, Figure 11

Figured specimen: Slide S3283, stage co-ordinates 11.5, 91.6; dimensions 101 × 66 μ. Co-ordinates of reference point 26.4, 84.1.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Remarks: Playford states (1965, p. 195) "In most specimens rugulae are more conspicuous than coni, but in a few the reverse is the case." In the specimen figured the sculptural pattern is of the latter type.

Distribution: Triassic of Tiers Formation, Tasmania (Playford, 1965); Triassic of Ipswich Coal Measures (Hill, Playford and Woods, 1965; de Jersey, 1970b, 1971b); Triassic of Esk Beds (this paper).

Aratrisporites paenulatus Playford and Dettmann, 1965

Plate 2, Figure 2

Figured specimen: Slide S3523, stage co-ordinates 17.3, 86.7; dimensions 38 × 28 μ. Co-ordinates of reference point 26.0, 83.8.

Locality: P.S. Baylam 1, sidewall core 28, 2157 feet.

Remarks: Balme has recently (1970, p. 352) reported this species from the Mianwali and Tredian Formations of the Salt Range, thereby extending its range back to the Early Triassic.

Distribution: Late Triassic of Leigh Creek Coal Measures, South Australia (Playford and Dettmann, 1965); Mianwali and Tredian Formations of the Salt Range, Pakistan (Balme, 1970). A specimen recorded as *Aratrisporites* sp. cf. *A. paenulatus* has been reported from the Tivoli Formation of the Ipswich Coal Measures (de Jersey, 1971b).

Aratrisporites rugulatus de Jersey, 1970

Plate 2, Figure 1

Figured specimen: Slide S3282, stage co-ordinates 21.7, 84.5; dimensions 48 × 36 μ.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Remarks: The specimen figured illustrates the distinctive close attachment of the two exine layers and the mixed rugulate-verrucate-conate sculpture. Only two specimens of the species have been observed in the Esk material.

Distribution: Triassic of upper Rewan Formation (de Jersey, 1970a); Early Triassic of Kockatea Shale, Western Australia (A. J. Williams, pers. comm.); Esk Beds (this paper).

Aratrisporites strigosus Playford, 1965

Plate 2, Figure 5

Figured specimen: Slide S3210, stage co-ordinates 11.0, 89.0; dimensions (lateral view) 53 × 33 μ. Co-ordinates of reference point 25.5, 85.1.

Locality: G.S.Q. Ipswich 17, 1203 feet 9 inches.

Remarks: The specimen figured conforms closely to Playford's description and figures of this species (Playford, 1965, pp. 195, 196; pl. 10, figs. 6-9). Some difficulty has been experienced in differentiating between this species and *A. paenulatus* Playford and Dettmann, 1965, in the Esk material. According to Playford (1965, p. 196) *A. strigosus* differs from the latter species "in possessing finer, more densely distributed, predominantly conate sculpture, together with a less distinct (thinner) inner layer." In the Esk assemblages there are specimens which appear to be intermediate, in these features, between the type populations of the two species. If continuous gradation in the intermediate forms could be demonstrated there would be grounds for regarding *A. strigosus* as a junior synonym of *A. paenulatus*. Unfortunately the overall preservation of the Esk material is not good enough for conclusive evidence for, or against, such continuous gradation, to be obtained. As Balme has indicated (1970, p. 352) in the case of *A. paenulatus*, one character at least—the density of sculptural processes—is likely to be affected by preservational differences. Consequently no final conclusion can be drawn on the relationship of these species and in the Esk material a somewhat arbitrary distinction has been made, on the

basis of the somewhat larger size, finer, predominantly conate sculpture and less distinct inner layer, of *A. strigosus*.

Distribution: Triassic of Tiers and Brady Formations of Tasmania (Playford, 1965); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, upper Rewan Formation (de Jersey, 1968, 1970a); Esk Beds (this paper).

Aratrisporites tenuispinosus Playford, 1965

Plate 2, Figure 3

Figured specimen: Slide S3308, stage co-ordinates 6.9, 85.0; dimensions 33 × 26 μ. Co-ordinates of reference point 26.5, 82.8.

Locality: G.S.Q. Ipswich 17, 2714 feet 2 inches.

Remarks: The specimen figured is the only example of this species observed in the Esk assemblages. It is similar to specimens previously recorded from the Clematis Sandstone (de Jersey, 1968, p. 11) and Rewan Formation (de Jersey, 1970a, p. 11).

Distribution: Triassic of Tiers Formation, Tasmania (Playford, 1965); basal Clematis Sandstone, uppermost Rewan Formation (de Jersey, 1968, 1970a); Esk Beds (this paper).

Aratrisporites wollariensis Helby, 1967

Plate 2, Figure 4

Figured specimen: Slide S3453, stage co-ordinates 14.8, 89.4; dimensions 35 × 30 μ. Co-ordinates of reference point 26.6, 83.9.

Locality: P.S. Baylam 1, sidewall core 24, 2203 feet.

Remarks: Distinctive features of this species are its small size, broadly elliptical to sub-circular amb and thin sculptine. Its morphology has been recently discussed and illustrated on the basis of material from the Rewan Formation (de Jersey, 1970a, pp. 11, 12; pl. 4, figs. 8, 9, 10, 12, 13).

Distribution: Triassic of Wollar Sandstone, Collaroy Claystone, and Hawkesbury Sandstone of New South Wales (Helby, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Esk Beds (this paper). The species is confined to the basal part of the Esk sections penetrated in G.S.Q. Ipswich 17 and P.S. Baylam 1.

Genus Polypodiisporites Potonié & Gelletich ex Potonié, 1956

Type species: Polypodiisporites favus (Potonié) Potonié & Gelletich, 1933.

Polypodiisporites ipsviciensis (de Jersey) Playford & Dettmann, 1965

Plate 2, Figure 6

Figured specimen: Slide S3209, stage co-ordinates 20.0, 93.6; dimensions 28 × 26 μ. Co-ordinates of reference point 21.1, 81.2.

Locality: G.S.Q. Ipswich 17, 1158 feet 9 inches.

Distribution: Widespread in Esk assemblages (this paper). For previous records see de Jersey (1971b, p. 13).

Genus Punctatosporites Ibrahim, 1933

Type species: Punctatosporites minutus Ibrahim, 1933.

Punctatosporites walkomi de Jersey, 1962

Plate 2, Figure 9

Figured specimen: Slide S3583, stage co-ordinates 7.1, 86.4; dimensions 25 × 21 μ. Co-ordinates of reference point 26.5, 82.6.

Locality: G.S.Q. Ipswich 17, 2858 feet 5 inches.

Distribution: Fairly common in some of the Esk assemblages. For previous records see de Jersey (1971b, p. 13).

Genus Tuberculatosporites Imgrund, 1952

Type species: Tuberculatosporites anicystoides Imgrund, 1952.

Tuberculatosporites aberdarensis de Jersey, 1964

Distribution: A rare component of the Esk assemblages. For previous records see de Jersey (1971b, p. 13).

Anteturma Variegerminantes Potonié, 1970

Turma Saccites Erdtman, 1947

Subturma Monosaccites Chitaley emend. Potonié & Kremp, 1954

Infraturma Aletesacciti Leschik, 1955

Genus Accinctisporites Leschik, 1955

Type species: Accinctisporites ligatus Leschik, 1955.

Accinctisporites ligatus Leschik, 1955

Plate 3, Figures 3 and 6

Figured specimen (*Plate 3, Figure 3*): Slide S3405, stage co-ordinates 21.8, 95.3; diameter 44 μ. Co-ordinates of reference point 25.8, 83.1.

Locality: P.S. Lockrose 1, Core 7, 2902 feet.

Figured specimen (*Plate 3, Figure 6*): Slide S3255, stage co-ordinates 21.4, 93.2; diameter 64 μ. Co-ordinates of reference point 27.2, 82.5.

Locality: G.S.Q. Ipswich 17, 1863 feet 2 inches.

Remarks: In distal focus this species appears somewhat similar to *Cordaitina gunyalensis* (Pant & Srivastava) Balme, recently described by Balme (1970, pp. 355-357) from the Triassic of the Salt Range. In *C. gunyalensis* the saccus is "detached equatorially with a wider overlap on one (? distal) face of the corpus than the other" (Balme, 1970, p. 357). However, in *A. ligatus*, as indicated by Clarke (1965, pp. 303, 304; text-fig. 5), the saccus covers the proximal face of the corpus, to which it is attached sub-equatorially on the distal face. This interpretation is supported by the morphology of a laterally compressed specimen figured by Jain (1968, pl. 2, fig. 37) and of another specimen figured by the writer (de Jersey, 1968, pl. 3, fig. 4). In the latter specimen, figured in proximal focus, the fine saccus reticulum is seen to extend over the proximal face of the corpus.

Distribution: Middle Keuper of Switzerland (Leschik, 1955); Lower Keuper of Worcestershire, England (Clarke, 1965); Middle and Late Triassic of East

Germany (Schulz, 1966); Middle Triassic of Cacheuta Formation, Argentina (Jain, 1968); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Esk Beds (this paper). In the Bowen Basin of Queensland, the species first appears near the Rewan-Clematis boundary (de Jersey, 1968, Figure 3).

Subturma DISACCITES Cookson, 1947

Genus ALISPORITES Daugherty, 1941

Type species: Alisporites opii Daugherty, 1941.

Remarks: The nomenclature of bisaccate grains assigned to *Alisporites* and *Falcisporites* has been briefly discussed in a recent paper on material from the Ipswich Coal Measures (de Jersey, 1971b, p. 15). Since preparation of this paper, papers by Balme (1970), Potonié (1970) and Jansonius (1971) expressing views on the circumscription of *Alisporites* and on the characters of its type species, have become available. Potonié (1970, p. 73) regards the holotype of the type species, *A. opii*, as monocolpate and supports the emendation of Somers (1968, p. 351). He summarises the features of the genus and the type species as follows:—

"Bisaccat, haploxylonoid, alet, moncolpat, Aquator ± ellipsoid, Colpus öfter, nicht immer, schmal, manchmal durch die Basalfalten der Sacci randlich bedeckt und dadurch nur scheinbar schmal. Kalotte wenig verdickt. Der Colpus der Typus erscheint nur deshalb besonders schmal, weil er von der basalen Saccusfalten teils bedeckt wird. Der Zentralkörper des Typus is nur darum schmal ellipsoid, weil er sekundar zusammengeschrumpt ist."

A different view is expressed by Balme (1970, p. 390) who states:

"Attempts to restrict *Alisporites* have been based on the assumption that *Alisporites opii* possesses a distal sulcus (Keimfurche). This feature was regarded as diagnostic of the genus in the emendation of Potonié and Kremp (1954), and Klaus (1963) stated that only disaccate pollen grains with a clear fusiform sulcus should be assigned to *Alisporites*. *Falcisporites* has a sulcus with rounded ends but otherwise is closely similar to Klaus' interpretation of *Alisporites*.

The main difficulty concerns the problem of determining whether or not *A. opii* possesses a sulcus in the sense of a sharply delimited area of the cappula with a distinct and more or less constant outline. A longitudinal rupture occurs on the holotype of *A. opii* (Daugherty, 1941, pl. 34, fig. 2), but this could represent a random rent in an undifferentiated cappula rather than a sulcus. Clearly Daugherty's type material needs restudy, but through the kindness of Dr. S. A. J. Pocock of Imperial Oil Company, Calgary, I have been able to examine a slide of plant microfossils from the Chinle Formation. This contains a number of disaccate pollen grains comparable in size and gross morphology to *A. opii*, and although their preservation is imperfect, I am unable to satisfy myself that any possess a distal sulcus. I conclude that if *Alisporites* is to be restricted, forms with a clearly defined distal sulcus should be excluded from it."

Following this conclusion that specimens of *A. opii* from the Chinle Formation are not sulcate, Balme (1970, p. 38) considered that the sulcate genus *Falcisporites* Leschik emend. Klaus, 1963 was a more suitable repository for specimens with a distal sulcus, such as his new species *F. stabilis*. He also inferred that *Alisporites australis* de Jersey, 1962, which resembles *F. stabilis* in having a clearly defined sulcus, should also be assigned to *Falcisporites*.

More recently, Jansonius (1971) has clarified the position by re-examining the holotype of *A. opii*. He finds that it is well preserved and records the presence of a distal sulcus; thus it seems likely that this feature was not observed by Balme (1970, p. 390) because of the imperfect preservation of his specimens of *A. opii*, from the Chinle Formation.

Jansonius (1971, p. 355) emphasises the significance of the presence of a distal sulcus, in distinguishing *Alisporites* from other bisaccate pollen of coniferous affinity. Consequently his re-examination provides strong evidence for retaining in *Alisporites* the species *A. australis* de Jersey, 1962, which has a clearly defined distal sulcus. This species also conforms in other features to Jansonius' view of the circumscription of *Alisporites*, except that a thin nexinal body, as is visible in *A. opii*, has not been recorded. However the writer considers that the distinctness of a nexinal body can be affected markedly by maturity, preservation and processing of the specimens and so may not be a reliable diagnostic criterion, at the generic level.

The same author (Jansonius, 1971, p. 356) has also re-examined a specimen of *Falcisporites zapfei* illustrated by Klaus (1963, pl. 18, fig. 86). He states: "The differences with *Alisporites* are significant; the saccus reticulation is much coarser, and the distal leptoma is delineated by distinct distal bladder bases; a thickening of the proximal exoexine along the longitudinal axis is also apparent." Accordingly if this specimen is representative of European species of *Falcisporites*, it should be possible to distinguish them from *Alisporites*, on the basis of these differences.

Alisporites spp.

Remarks: Although they undoubtedly contain representatives of *Alisporites australis* de Jersey, 1962, no attempt has been made to differentiate, specifically, grains assigned to this genus, in the Esk assemblages. Previous study has suggested that such specific differentiation has little, if any, stratigraphic application, within the Triassic of Queensland.

Genus CHORDASPORITES Klaus, 1960

Type species: Chordasporites singulichorda Klaus, 1960.

Chordasporites australiensis de Jersey, 1962

Remarks: This species is a rare component of the Esk assemblages.

Distribution: Triassic of Ipswich Coal Measures (de Jersey, 1962, 1970b, 1971b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Esk Beds (this paper).

Genus INDUSIISPORITES Leschik, 1955

Type species: Indusiisporites velatus Leschik, 1955.

Indusiisporites sp.

Plate 4, Figure 7

Figured specimen: Slide S3452, stage co-ordinates 24.2, 94.7; dimensions of corpus 56 × 38 μ. Co-ordinates of reference point 26.4, 83.0.

Locality: P.S. Baylam 1, sidewall core 24, 2203 feet.

Remarks: The specimen figured is representative of grains in the Esk assemblages, assigned to this genus. Specific differentiation has not been attempted.

Genus PLATYSACCUS Naumova ex Potonié & Klaus, 1954

Type species: Platysaccus papilionis Potonié & Klaus, 1954.

Platysaccus queenslandi de Jersey, 1962

Plate 3, Figure 5

Figured specimen: Slide S3299, stage co-ordinates 26.1, 87.5; total span 71 μ. Co-ordinates of reference point 27.8, 83.9.

Locality: G.S.Q. Ipswich 17, 2474 feet 6 inches.

Distribution: Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1962, 1964, 1970b, 1971b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Tasmania (Playford, 1965); Triassic of Cacheuta Formation, Argentina (Jain, 1968); Triassic of Nidpur, India (Bharadwaj and Srivastava, 1969); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Esk Beds (this paper); Triassic of Mianwali and Tredian Formations, Salt Range, Pakistan (Balme, 1970); Triassic and Jurassic of Leigh Creek Coal Measures (Playford and Dettmann, 1965); Jurassic of Helidon Sandstone (de Jersey, 1971a).

Genus PROTODIPLOXYPINUS Samoilovitch emend. Scheuring, 1970

Type species: Pinojella bialinina Malyavkina, 1949.

Protodiploxypinus sp. cf. *P. schizeatus* (Mädler) Scheuring, 1970

Plate 3, Figure 7

Figured specimen: Slide S3281, stage co-ordinates 14.6, 100.3; total span 54 μ. Reference point 26.0, 82.8.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Remarks: The transference of *Minutosaccus schizeatus* Mädler, 1964 (Mädler, 1964, p. 120; pl. 12, figs. 4, 5) to *Protodiploxypinus* by Scheuring (1970, p. 71) is supported here. The specimen figured has sacci which appear slightly larger, relative to the corpus, than in the figures of *P. schizeatus*; it resembles Mädler's species in all other features.

Distribution of P. schizeatus: Lower Keuper of Germany (Mädler, 1964).

Genus SULCOSACCISPORA Klaus, 1964

Type species: Sulcosaccispora minuta Klaus, 1964.

Sulcosaccispora alaticonformis (Malyavkina) de Jersey, 1968

Plate 3, Figure 4

Figured specimen: Slide S3283, stage co-ordinates 7.8, 86.8; dimensions 40 × 43 μ. Co-ordinates of reference point 7.8, 86.8.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Remarks: This species is widely distributed in the Esk assemblages, as it is in Middle Triassic microfloras of the Bowen Basin. It is relatively rare in Late Triassic assemblages from the Ipswich Coal Measures and lower Bundamba Group.

Distribution: Early and Middle Triassic of U.S.S.R. (Malyavkina, 1964); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1970b, 1971b); Triassic of Hawkesbury Sandstone and Wianamatta Group of Sydney Basin (Helby, in press); Esk Beds (this paper).

Genus VITREISPORITES Leschik emend. Jansonius, 1962

Type species: Vitreisporites signatus Leschik, 1955.

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Distribution: Widespread in Mesozoic sediments, Esk Beds (this paper). For previous Queensland records see de Jersey (1970a, p. 16; 1971b, p. 15).

Genus VOLTZIACEAESPORITES Klaus, 1964

Type species: Voltziaceaesporites heteromorpha Klaus, 1964.

Voltziaceaesporites heteromorpha Klaus, 1964

Plate 4, Figure 6

Figured specimen: Slide S3260, stage co-ordinates 16.9, 95.9; total span 97 μ. Co-ordinates of reference point 25.8, 83.8.

Locality: G.S.Q. Ipswich 17, 1661 feet 2 inches.

Remarks: The specimen figured is similar to a European specimen figured by Visscher (1966, pl. 8, fig. 5).

Distribution: Buntsandstein and Muschelkalk of France, Germany, and Austria (Klaus, 1964); Middle and Late Scythian, Anisian, and Ladinian of Alpine Triassic (Klaus, 1965); Upper Buntsandstein and Muschelkalk of the Netherlands (Visscher, 1966; Visscher and Commissaris, 1968); Middle Buntsandstein of Thuringia, Germany (Reinhardt and Schön, 1967); Upper Buntsandstein and Muschelkalk of East Germany (Schulz, 1966); Clematis Sandstone, middle and upper Rewan Formation of Bowen Basin (de Jersey, 1968, 1970a); Esk Beds (this paper). A form listed as *Voltziaceaesporites* sp. cf. *V. heteromorpha* has been recorded by de Jersey and Hamilton (1969, p. 23) from subsurface equivalents of the Moolayember Formation (the "Wandoan Formation").

Subturma STRIATITES Pant, 1954

Remarks: The Esk assemblages contain a small, but persistent proportion of striate bisaccate pollen grains. Although many of them are poorly preserved it is apparent that there is some variety in the species present, which include representatives of the genera *Lunatisporites*, *Lueckisporites*, *Protohaploxypinus*, and *Striatoabietites*.

It is probable that these grains are indigenous components of the microflora, and not recycled from Permian strata, as there is no evidence for the recycling of other Permian species, and, furthermore, they include a high proportion of *Lunatisporites*, a genus unknown from Permian assemblages in Australia.

The presence of these striate species in the Esk assemblages is of stratigraphic interest. It is in conformity with a progressive decline in the abundance and variety of grains of this type through the Australian Triassic sequence. In the Lower Triassic Rewan Formation (and strata of equivalent age in other states) striate species are abundant, or even dominant, in the assemblages. In the Middle Triassic Moolayember and Esk assemblages their proportions are much reduced, but several species are represented, while in the Late Triassic Ipswich microflora only one long-ranged species—*Hamiapollenites insculptus*—has survived.

Genus LUECKISPORITES Potonié & Klaus emend. Klaus, 1963

Type species: Lueckisporites virkkiae Potonié & Klaus emend. Klaus, 1963.

Lueckisporites sp.

Plate 3, Figure 8

Figured specimen: Slide S3213, stage co-ordinates 23.5, 93.6; total span 71 μ. Co-ordinates of reference point 26.6, 82.3.

Locality: G.S.Q. Ipswich 17, 1203 feet 9 inches.

Remarks: The specimen figured is the only representative of this genus in the Esk assemblages. It appears to be distinct from previously described species and from a Rewan specimen recorded as *Lueckisporites* sp. cf. *L. tattooensis* Jansonius (de Jersey, 1970a, p. 16, pl. 7 fig. 5).

Genus LUNATISPORITES Leschik emend. Scheuring, 1970

Type species: Lunatisporites acutus Leschik, 1955.

Remarks: Mädler (1964) and Visscher (1966) stressed the significance of the presence or absence of a monolete mark on the intexine, in generic classification of the Striatites. As the presence of such a monolete mark had not been recorded in the type material of *Lunatisporites* (and its synonym *Taeniaesporites*) Mädler's genus *Striatisaccus* was used by the writer (de Jersey, 1968, 1970a) to accommodate Queensland Triassic species, which have a monolete intexine. Recently, however, Scheuring (1970, p. 50, pl. 8, figs. 37, 38) has demonstrated the presence of a monolete intexine in a specimen of *L. acutus* from one of Leschik's original preparations, supporting the view that the absence of this feature in Leschik's type material is due to poor preservation. Consequently there is now no longer justification for separating *Striatisaccus* from *Lunatisporites* and Queensland species assigned to the former taxon (de Jersey, 1968, pp. 18, 19; 1970a, pp. 17, 18) should be placed in *Lunatisporites* Leschik emend. Scheuring, 1970.

Only one species, *Lunatisporites pellucidus* (Goubin) Helby, comb. nov. is recorded from the Esk material; the remaining specimens of the genus are not specifically identifiable.

Lunatisporites pellucidus (Goubin) Helby, comb. nov.

Plate 3, Figure 9

1965 *Protohaploxypinus pellucidus* Goubin, p. 1423, pl. 2, figs. 4-6.

1970 *Taeniaesporites pellucidus* (Goubin) Balme, p. 373, pl. 13, figs. 8-10.

Figured specimen: Slide S3422, stage co-ordinates 20.9, 95.9; total span 73 μ. Co-ordinates of reference point 26.9, 83.7.

Locality: P.S. Lockrose 1, Core 11, 4004 feet.

Remarks: Balme (1970, p. 373) transferred this species as a new combination from *Protohaploxypinus* to *Taeniaesporites*, on the grounds that it has essentially four major taeniae, although those bordering the polar cleft are not infrequently subdivided by narrower, subsidiary clefts so that five or even six taeniae may be present. This view of the morphology of the species is supported here; it has been reassigned to *Lunatisporites* (Helby, in press), as Visscher (1966, p. 358) has clearly demonstrated that *Taeniaesporites* is a synonym of *Lunatisporites*.

The specimen figured, from the lower part of the Esk sequence in P.S. Lockrose 1, conforms closely to Balme's (1970, p. 373) description of this species.

Distribution: Early and Middle Triassic of Sakamena Group, Madagascar (Goubin, 1965); Early and Middle Triassic of Mianwali and Tredian Formations, Salt Range, Pakistan (Balme, 1970); Early Triassic of Kockatea Shale, Perth Basin, Western Australia (Balme, 1963); Early Triassic of Narrabeen Group, Sydney Basin (Helby, in press); Esk Beds (this paper).

Genus PROTOHAPLOXYPINUS Samoilovitch, 1953

Type species: Pemphygaletes latissimus Luber, in Luber and Valts, 1941.

Remarks: Four poorly preserved specimens are assigned to this genus; none is specifically identifiable.

Genus STRIATOABIETITES Sedova, 1956

Type species: Striatoabietites brickii Sedova, 1956.

Remarks: One poorly preserved specimen of this genus is recorded.

Turma ALETES Ibrahim, 1933

Subturma AZONALETES Luber emend. Potonié & Kremp, 1954

Infraturma PSILONAPITI Erdtman, 1947

Genus GREBESPORA Jansonius, 1962

Type species: Grebespora concentrica Jansonius, 1962.

Grebespora concentrica Jansonius, 1962

Plate 4, Figure 2

Figured specimen: Slide S3487, stage co-ordinates 25.0, 84.3; diameter 46 μ. Co-ordinates of reference point 26.6, 80.9.

Locality: P.S. Baylam 1, sidewall core 9, 1362 feet.

Distribution: Early Triassic of Western Canada (Jansonius, 1962); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Triassic of Esk Beds (this paper).

Genus INAPERTUROPOLLENITES Pflug ex Thomson & Pflug emend. Potonié, 1966

Type species: Inaperturopollenites dubius (Potonié & Venitz) Thomson & Pflug emend. Potonié, 1966.

Inaperturopollenites spp.

Remarks: Smooth or scabrate, inaperturate grains are recorded under this heading; specific differentiation has not been attempted.

Infraturma GRANULONAPITI Cookson, 1947

Genus ARAUCARIACITES Cookson ex Couper, 1953

Type species: Araucariacites australis Cookson, 1947.

Araucariacites spp.

Remarks: Under this heading are recorded poorly preserved specimens, with sculpture of grana, rather than coni, as in *Conaletes*.

Genus CONALETES Reinhardt & Schön, 1967

Type species: Conaletes apiculatus Reinhardt & Schön, 1967.

Conaletes spp.

Remarks: Specific differentiation of these grains has not been attempted.

Infraturma CIRCUMPOLLINI Pflug emend. Klaus, 1960

Genus DISCISPORITES Leschik emend. de Jersey, 1964

Type species: Discisporites niger Leschik, 1955.

Discisporites psilatus de Jersey, 1964

Plate 4, Figure 1

Figured specimen: Slide S3256, stage co-ordinates 22.0, 87.9; diameter 26 μ. Co-ordinates of reference point 27.6, 84.0.

Locality: G.S.Q. Ipswich 17, 1863 feet 2 inches.

Remarks: The specimen figured exhibits well developed concentric distal folds adjacent to a distinct rimula. These distal folds are similar to the concentric fold of a specimen from the Tivoli Formation of the Ipswich Coal Measures recorded as cf. *Discisporites psilatus* (de Jersey, 1971b, pp. 15, 16, pl. 4, fig. 2). As in the case of this Tivoli specimen (de Jersey, 1971b, p. 16) these concentric folds are suggestive of a transition to *Grebespora concentrica* Jansonius (which has a similar concentric fold and may exhibit a vestigial trilete mark). The latter species is also present in the Esk assemblages.

Distribution: Triassic of Raceview Formation, Ripley Road Sandstone (de Jersey, 1964, 1970b, 1971a); Triassic of Esk Beds (this paper).

Turma PLICATES Naumova emend. Potonié, 1960

Subturma COSTATES Potonié, 1970

Infraturma COSTATI Potonié, 1966

Genus EQUISETOSPORITES Daugherty emend. Pocock & Jansonius, 1964

Type species: Equisetosporites chinleana Daugherty, 1941.

Remarks: Emended generic diagnoses and discussions of the taxonomic status of *Equisetosporites* were published independently by Pocock and Jansonius (in Pocock, 1964, pp. 143-145) and Singh (1964, pp. 129-131) The emended diagnosis of the former authors is preferred.

Equisetosporites steevesi (Jansonius) de Jersey, 1968

Plate 5, Figures 1 and 2

Figured specimen (*Plate 5, Figure 1*): Slide S3256, stage co-ordinates 22.6, 88.3; dimensions 66 $\times$ 35 μ. Co-ordinates of reference point 27.6, 84.0.

Locality: G.S.Q. Ipswich 17, 1863 feet 2 inches.

Figured specimen (*Plate 5, Figure 2*): Slide S3300, stage co-ordinates 10.5, 101.5; dimensions 66 $\times$ 25 μ. Co-ordinates of reference point 23.1, 82.1.

Locality: G.S.Q. Ipswich 17, 2474 feet 6 inches.

Remarks: The Esk specimens are similar to the Canadian material described by Jansonius (1962, p. 77) and to specimens from the Bowen Basin of Queensland (de Jersey and Hamilton, 1967, p. 19; de Jersey, 1968, pp. 20, 21; de Jersey, 1970a, p. 21). One of the specimens figured (Plate 5, Figure 1) has a shrunken inner layer; as discussed previously (de Jersey, 1968, p. 21) such grains are regarded as preservational variants of *E. steevesi*. The size range of the Esk specimens (based on fourteen measured specimens) is from 38 to 68 μ (length) $\times$ 16 to 35 μ (breadth).

Distribution: Early Triassic of Western Canada (Jansonius, 1962); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone, Rewan Formation (de Jersey, 1968, 1970a); Esk Beds (this paper). Helby (in press) has recorded the species from the Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group of the Sydney Basin.

Subturma MONOCOLPATES Wodehouse, Iversen & Troels-Smith, 1953

Genus BRACHYSACCUS Mädler, 1964

Type species: Brachysaccus ovalis Mädler, 1964.

Remarks: Potonié (1970, pp. 98, 99) has re-interpreted the morphology of this genus on the basis of re-examination of the original material of the type species. He has demonstrated that the grains are not bisaccate, but monocolpate, with the colpus extending through more than one hemisphere. The exine is thicker than in Cycadophyte pollen and has a fine infrareticulum. This

interpretation is followed here; grains of *Brachysaccus eskensis* sp. nov., described below, are of the same general construction as the type species, differing only in features significant at the specific level.

With the exception of *B. aurentius* (Pautsch) Mädler, 1964, the other species assigned to *Brachysaccus* by Mädler (1964) are obviously saccate and should be excluded from the genus, in accordance with Potonié's interpretation.

Brachysaccus eskensis sp. nov.

Plate 4, Figures 3, 4 and 5

Diagnosis: Monocolpate pollen grains. Amb broadly oval, with rounded extremities, dimensions (based on 10 measured specimens) 68 — 119 × 44 — 106 μ. Colpus present over full length of distal face (in direction of longer axis) and extending slightly on to proximal face in the form of irregular cracks in the exine. Exine 2 — 5 μ thick at equator, slightly thinner adjacent to colpus, with a fine internal reticulum. Lumina of infrareticulum about 1 μ.

Holotype (*Plate 4, Figure 4*): Slide S3281, stage co-ordinates 24.7, 83.7; dimensions 86 × 63 μ. Co-ordinates of reference point 26.0, 82.8.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Figured specimen (*Plate 4, Figure 5*): Slide S3284, stage co-ordinates 25.5, 88.5; dimensions (overall) 106 × 106 μ. Co-ordinates of reference point 27.4, 83.4.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Figured specimen (*Plate 4, Figure 3*): Slide S3269, stage co-ordinates 7.2, 100.7; dimensions 77 × 66 μ. Co-ordinates of reference point 27.4, 83.0.

Locality: G.S.Q. Ipswich 17, 1994 feet 6 inches.

Remarks: The holotype (Plate 4, Figure 4) illustrates a complete, unbroken specimen of the species. Because of the long extension of the colpus, there is a tendency for the exine to split longitudinally; an extreme case of this splitting is illustrated in Plate 4, Figure 5, which shows a specimen split into two longitudinal portions. The other figure (Plate 4, Figure 3) illustrates portion of a specimen with a well defined infrareticulum.

Brachysaccus eskensis differs from the type species, *B. ovalis* Mädler, 1964, described from the upper Buntsandstein of Germany, in being significantly smaller in overall dimensions and in having a thinner exine and finer infrareticulum. *B. aurentius* (Pautsch) Mädler, 1964 from the Keuper of Poland (Pautsch, 1958, p. 323) is distinguished from both these species by its large size and subcircular amb.

Distribution: Esk Beds (this paper).

Genus CYCADOPITES Wodehouse ex Wilson & Webster, 1946

Type species: Cycadopites follicularis Wilson & Webster, 1946.

Remarks: As indicated recently (de Jersey, 1971b, p. 18) the writer has followed the broad interpretation of Jansonius (1962, p. 80) who included in this genus grains ranging from broadly oval to fusiform in outline and having smooth, ornamented or intrapunctate exines. It was pointed out (de Jersey, 1971b, p. 17) that grains of this type, which appear unsculptured on examination with the light microscope, may reveal fine sculpture, if studied with the scanning electron microscope. Furthermore, sculpture evident from study with the light microscope may be shown more clearly in Stereoscan study. Accordingly it seems desirable to await a comprehensive study of the surface sculpture of grains of this type, with the aid of the scanning electron microscope, before finally defining more restricted generic units. Such an investigation should include material from the type locality of the type species, *Cycadopites follicularis* Wilson & Webster, 1946.

Cycadopites crassimarginis (de Jersey) de Jersey, 1964

Distribution: Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1962, 1964, 1970b, 1971b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Esk Beds (this paper).

Cycadopites granulatus (de Jersey) de Jersey, 1964

Distribution: Triassic of Ipswich Coal Measures, lower Bundamba Group (de Jersey, 1962, 1964, 1971a, 1971b); Triassic of Tingalpa and Moorooka Formations, Brisbane area (de Jersey and Hamilton, 1965b); Middle Triassic of Moolayember Formation (de Jersey and Hamilton, 1967); Triassic of Clematis Sandstone (de Jersey, 1968); Triassic of Esk Beds (this paper); Jurassic of Marburg Formation (de Jersey, 1971a).

Cycadopites nitidus (Balme) de Jersey, 1964

Plate 5, Figure 8

Figured specimen: Slide S3581, stage co-ordinates 20.3, 93.8; dimensions 49 × 30 μ. Co-ordinates of reference point 27.2, 83.0.

Locality: G.S.Q. Ipswich 17, 2858 feet 5 inches.

Remarks: Both Balme (1970, p. 412) and Helby (in press) have regarded this species as a synonym of *Cycadopites follicularis* Wilson and Webster, 1946. Certainly there is little to distinguish the species, on the basis of described features. However the writer has recently observed (de Jersey, 1971b, p. 17) fine sculpture, near the limit of resolution of the light microscope, in a Queensland Triassic species, *C. tivoliensis*, and the possibility exists that even finer sculptural elements, not visible with the light microscope, may be revealed by Stereoscan study of other species of *Cycadopites*. A comprehensive re-examination, with the aid of the scanning electron microscope, of material from the type localities of *C. follicularis* and *C. nitidus*, and other material assigned to these species, seems desirable before final conclusions can be drawn on specific grouping. Provisional retention of *C. nitidus* as a separate entity for Australian Mesozoic grains may assist such an investigation.

Distribution: Esk Beds (this paper); for previous Queensland records see de Jersey (1971a, p. 20).

Cycadopites sp. cf. *C. potoniei* Bharadwaj & Singh, 1964

Plate 5, Figure 7

Figured specimen: Slide S3308, stage co-ordinates 18.4, 87.6; dimensions 109 × 50 μ. Co-ordinates of reference point 26.5, 82.8.

Locality: G.S.Q. Ipswich 17, 2714 feet 2 inches.

Remarks: The specimen figured has a thicker exine than *Cycadopites potoniei*, but otherwise conforms to the description and figures of the European species, recorded by Bharadwaj and Singh (1964, p. 39, pl. 5, figs. 105, 106) from Upper Triassic coals of Lunz, Austria.

Distribution: Esk Beds (this paper).

Turma POROSES Naumova emend. Potonié, 1960

Subturma MONOPORINES Naumova, 1939

Genus PILASPORITES Balme & Hennelly emend. Jain, 1968

Type species: Pilasporites calculus Balme & Hennelly, 1956.

Pilasporites crateraformis Jain, 1968

Plate 5, Figure 6

Figured specimen: Slide S3396, stage co-ordinates 10.2, 80.4; diameter 64 μ. Co-ordinates of reference point 26.3, 81.0.

Locality: P.S. Lockrose 1, Core 5, 2205 feet.

Remarks: The figured specimen is the only specimen assigned to this species in the Esk material. A much smaller specimen from P.S. Lockrose 1 (Core 11, 4004 feet) is recorded as *Pilasporites* sp. cf. *P. crateraformis*, as its diameter (30 μ) is appreciably below the recorded size range of the species.

Distribution: Middle Triassic of Cacheuta Formation, Argentina (Jain, 1968); Triassic of Tarong Beds (de Jersey, 1970c); Triassic of Ipswich Coal Measures (de Jersey, 1971b); Triassic of Esk Beds (this paper).

Pilasporites sp. A

Plate 5, Figure 9

Figured specimen: Slide S3281, stage co-ordinates 15.7, 99.1; diameter 48 μ. Co-ordinates of reference point 26.0, 82.8.

Locality: G.S.Q. Ipswich 17, 2387 feet 6 inches.

Remarks: The specimen figured is similar to *Pilasporites crateraformis* Jain, 1968, recorded above, except that the circular opening is much smaller, in relation to the diameter of the amb, than in that species. As only two specimens have been observed, there is insufficient material for formal taxonomic treatment.

Distribution: Esk Beds (this paper).

Group ACRITARCHA Evitt, 1963

Subgroup ACANTHOMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus MICRHYSTRIDIUM Deflandre emend. Sarjeant, 1967

Micrhystridium sp.

Plate 5, Figure 4

Figured specimen: Slide S3486, stage co-ordinates 10.2, 85.2; diameter of shell 20-21 μ, length of spines 2-3 μ. Co-ordinates of reference point 26.5, 82.4.

Locality: P.S. Baylam 1, sidewall core 9, 1362 feet.

Remarks: Two specimens, from one sample, are assigned to this genus. The specimen figured shows some similarity in overall size and in length of the spines to *M. setasessitante* Jansonius, 1962, recorded by Jansonius (1962, p. 85) from Lower Triassic sediments in Western Canada and by Sarjeant (1970, p. 284) from the uppermost Permian of the Salt Range, Pakistan.

Subgroup POLYGONOMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus VERYHACHIUM Deunff emend. Downie & Sarjeant, 1963

Remarks: This genus is recorded here from two of the Esk samples (G.S.Q. Ipswich 17, 2714 feet 2 inches, and 2858 feet 5 inches), two specimens having been observed in each assemblage. Sarjeant (1970, p. 301) mentions evidence that the *Polygonomorphitae* (*Veryhachium*) favoured an open-sea environment. The presence of *Veryhachium* is thus of interest, in relation to the environment of deposition of the Esk Beds, as these sediments were laid down in the Upper Brisbane Valley Fault Trough and are regarded as entirely terrestrial (Hill, 1960, pp. 269-271). As the evidence for a terrestrial origin of the Esk Beds is impressive (namely the abundance of leaf fossils of land plants, presence of coal seams, and absence of any other marine fossils) two alternative explanations for the presence of these acritarchs are suggested. They are — (1) that they are reworked from marine sediments of the Permian fault blocks bordering the Esk Trough, or (2) that the species recorded provide evidence of an extremely brief marine transgression, or transgressions.

Veryhachium valensii (Valensi) emend. Downie & Sarjeant, 1964

Plate 5, Figure 5

Figured specimen: Slide S3582, stage co-ordinates 13.7, 98.8; side of shell 18 μ, spines 5-6.5 μ. Co-ordinates of reference point 27.4, 84.4.

Locality: G.S.Q. Ipswich 17, 2858 feet 5 inches.

Remarks: Dr. W. A. S. Sarjeant (pers. comm.) has confirmed the identification of the specimen figured with *V. valensii.*

Range of valensii: Permian to Upper Jurassic (Sarjeant, 1970).

Veryhachium sp. A

Plate 5, Figure 3

Figured specimen: Slide S3312, stage co-ordinates 10.0, 98.7; side of shell 31 μ, spines 10 μ. Co-ordinates of reference point 26.2, 80.1.

Locality: G.S.Q. Ipswich 17, 2714 feet 2 inches.

Remarks: The two specimens observed are appreciably larger than those recorded above as *Veryhachium* sp. cf. *V. valensii.*

Subgroup SCHIZOMORPHITAE Segroves, 1967

Genus CIRCULISPORITES de Jersey emend. Norris, 1965

Circulisporites parvus de Jersey emend. Norris, 1965

Remarks: Only one specimen of this species has been recorded in the Esk assemblages.

Distribution: Esk Beds (this paper). For other Queensland records see de Jersey (1971b, p. 18).

COMPARISON WITH OTHER AUSTRALIAN TRIASSIC MICROFLORAS

In a recent paper (de Jersey, 1971b, pp. 19-22) palynological evidence on the ages of Queensland Triassic microfloras has been discussed. This evidence indicates an Early to Middle Triassic age for the Triassic formations of the Bowen Basin (the Rewan Formation, Clematis Sandstone, and Moolayember Formation) and a Late Triassic age for sediments in the Ipswich area (the Ipswich Coal Measures and basal Bundamba Group). The elapse of a significant time interval between deposition of the Moolayember Formation and Ipswich Coal Measures is indicated by marked differences between assemblages from the two units (de Jersey, 1971b, p. 19).

Comparison of the assemblages now recorded from the Esk Beds with these two groups of Triassic microfloras indicates that they are similar to those recorded from the Bowen Basin, rather than to those of the Ipswich Coal Measures. Species in the Esk microflora, also recorded from the Bowen Basin, but absent from the Ipswich assemblages, include *Accinctisporites ligatus*, *Apiculatisporis clematisi*, *Aratrisporites rugulatus*, *A. strigosus*, *A. tenuispinosus*, *A. wollariensis*, *Equisetosporites steevesi*, *Foveosporites mimosae*, *Grebespora concentrica*, *Guttatisporites visscheri*, *Indospora clara*, *Kraeuselisporites saeptatus*, *K. verrucifer*, *Nevesisporites limatulus*, *Rugulatisporites trisinus*, and *Voltziaceaesporites heteromorpha*. On the other hand, Ipswich species, not recorded in the Esk assemblages, nor in those of the Bowen Basin, include *Acanthotriletes bradiensis*, *Anapiculatisporites pristidentatus*, *Annulispora folliculosa*, *A. microannulata*, *Apiculatisporis globosus*, *Aratrisporites flexibilis*, *Cadargasporites baculatus*, *Craterisporites rotundus*, *Cycadopites tivoliensis*, *Polycingulatisporites densatus*, and *Stereisporites perforatus*. An additional difference is that *Duplexisporites problematicus*, which is common in most assemblages from the Ipswich shales, is much less abundant, or absent in the Esk assemblages. It was the absence of this species, in an assemblage from Core 11 of P.S. Lockrose 1, which led the writer to suggest that the Esk sequence was older than that of the Ipswich Coal Measures (in Patterson, 1966a). This suggestion is now confirmed by the present detailed study.

Within the Bowen Basin sequence, the Esk assemblages show closest similarity to those of the Moolayember Formation. They lack the great abundance and variety of Striatites, which characterize the lower Rewan Formation, and also the abundance of *Aratrisporites* recorded from the upper part of that formation (de Jersey, 1970a), as well as other distinctive Rewan species. Higher in the Bowen Basin sequence, the initial appearance of *Duplexisporites problematicus* is of value in correlation. In the sections studied by de Jersey and Hamilton (1967) and de Jersey (1968) this species first appears near the base of the Moolayember Formation and persists in low proportions through that unit. Although somewhat sporadic in its distribution, and absent from some of the assemblages, it is useful in correlation studies, provided sufficient samples are examined to give a general indication of its distribution. This species is present almost to the base of the Esk section penetrated in G.S.Q. Ipswich 17; its occurrence thus indicates that this section is post-Clematis in age. The same species is present in the upper parts of the Esk sections penetrated in P.S. Baylam 1 and P.S. Lockrose 1. Undue significance should not be attached to its absence from deeper samples from these wells as relatively few cores were available in the lower parts of the well sections. Moreover, other elements of the assemblages concerned indicate that they are not significantly older than those of the better documented section of G.S.Q. Ipswich 17.

The three sections of the Esk Beds examined range from about 1300 feet to 3000 feet in vertical thickness. This is appreciably thinner than the section of the Moolayember Formation in the Mimosa Syncline (about 6000 feet) studied by de Jersey and Hamilton (1967). In addition, the Esk sections include a high proportion of conglomerate, which is of minor significance in the Moolayember sequence, so that it seems probable that these Esk sections required shorter time intervals for their deposition than the Moolayember sequence in the Mimosa Syncline. This is borne out by the miospore assemblages. De Jersey and Hamilton (1967, p. 22) found that four species were confined to the lower half of the Moolayember sequence which they examined. These species are *Aratrisporites wollariensis*, *Lophotriletes novicus*, *Tigrisporites playfordi*, and *Rugulatisporites trisinus*. Assuming that these species exhibit a similar pattern of distribution in the Esk sequence, their occurrence in the Esk assemblages favours the view that the sections studied can be correlated with the upper part of the Moolayember sequence.

This conclusion is illustrated by the distribution of these four species in G.S.Q. Ipswich 17, which provided the most complete record of the three sections studied. With the exception of *T. playfordi*, which is entirely absent, these species are largely confined to the basal 600 feet of the section. Although *L. novicus* and *R. trisinus* have each been recorded from one assemblage, higher in the section, they are extremely rare, the records being based on a single specimen in each case. Accordingly it is concluded that the base of the Esk section in G.S.Q. Ipswich 17 is approximately equivalent to the middle of the Moolayember sequence of de Jersey and Hamilton (1967) and that the top of this Esk section is no younger than horizons within the Moolayember sequence. This correlation is supported by the less detailed evidence of the assemblages from the other two sections and is illustrated diagrammatically in Figure 2.

Elsewhere in Australia, the microfloras most closely comparable with the Esk assemblages are from the Sydney Basin, where Helby (in press) has recorded assemblages of similar aspect from the Hawkesbury Sandstone and Wianamatta Group. In this basin *Duplexisporites problematicus* first appears within the Hawkesbury Sandstone; the overlying sequence in the Sydney Basin in thus regarded as approximately equivalent to the Moolayember Formation and hence to the Esk Beds, in the sections studied. No close comparison can be made with the Late Triassic microflora from Leigh Creek, South Australia, described by Playford and Dettmann (1965), nor with that from the Lower Triassic Kockatea Shale of the Perth Basin, recorded by Balme (1963). As indicated by de Jersey and Hamilton (1967, p. 23), an assemblage from the Tiers Formation of Tasmania, recorded by Playford (1965), appears to be of slightly older aspect than the Moolayember microflora.

Recently, Balme (1969) has provided a summary of the Triassic stratigraphy of Western Australia and has briefly mentioned general features of the microfloral assemblages. Further information on the assemblages is necessary to enable comparison with the Queensland microfloras; sections containing possible time equivalents of the Esk Beds occur in the Carnarvon Basin (the Mungaroo Beds) and in the Perth Basin (the Woodada Formation and Lesueur Sandstone).

AGE OF THE ESK BEDS

As the Moolayember Formation was assigned to the Middle Triassic by de Jersey and Hamilton (1967, p. 24), the above evidence for correlation of the Esk Beds with the upper part of this formation indicates a Middle Triassic age for the Esk sediments. More directly, the same age is indicated by consideration of the known ranges of species in the Esk assemblages. Species particularly important from this aspect are those recorded from accurately dated Triassic sequences in Europe and North America. As pointed out recently (de Jersey, 1971b, p. 20), there is a significant proportion of miospore species common to both Australian and Northern (European and North American) microfloras, even though the former contain many forms of Southern (Gondwana) aspect. Species in the Esk assemblages which are also present in the Northern microfloras include *Accinctisporites ligatus*, *Equisetosporites steevesi*, *Grebespora concentrica*, and *Voltziaceaesporites heteromorpha*. The evidence from these species on the age of the assemblages, within the Triassic, may be summarized as follows:—

Accinctisporites ligatus is known from the Middle and Late Triassic of Europe; it first appears at the base of the Muschelkalk (Schulz, 1966). In the southern hemisphere it is known from the Bowen Basin of Queensland (the Clematis Sandstone and Moolayember Formation) and the Cacheuta Formation (Middle Triassic) of Argentina (Jain, 1968). The other European species, *Voltziaceasporites heteromorpha*, ranges from middle Scythian to Ladinian. Although Klaus (1964, p. 129) recorded very rare specimens from the Keuper, it has not been recorded from the Late Triassic of Europe by other workers, some of whom (e.g., Scheuring, 1970) have made very detailed studies of assemblages from this part of the Triassic sequence. Accordingly for purposes of regional correlation it is regarded as essentially an Early and Middle Triassic species. It has been recorded, in Queensland, from the Rewan Formation and Clematis Sandstone and is probably represented in sub-surface equivalents of the Moolayember Formation (de Jersey and Hamilton, 1969, p. 23). The other two species, *Equisetosporites steevesi* and *Grebespora concentrica*, were described by Jansonius (1962) from sediments in Western Canada regarded as Scythian to Anisian in age. They have not been recorded from Late Triassic microfloras.

The association of these four species consequently favours a Middle Triassic age for the Esk assemblages. This evidence is strengthened by the absence of *Apiculatisporis globosus* and *Stereisporites perforatus*, which first appeared in Europe in sediments of Karnian age, and by the presence of *Lunatisporites pellucidus*, which has been recorded only from the Early and Middle Triassic (in Madagascar and Pakistan).

Evidence for the age of the Esk microflora, within the Middle Triassic, is less conclusive. However the assemblages contain a significant proportion of species, originally described from microfloras of Early Triassic age. The presence of these species, as remnants of the Early Triassic assemblages, favours an early Middle (Anisian), rather than a late Middle (Triassic) age. This view is supported by the marked differences between the Esk assemblages and those of the Ipswich Coal Measures, regarded as Karnian in age (de Jersey, 1971b, p. 20).

From the above conclusion it is clear that the microfloral evidence supports the recent view of Whitaker (1972) that the Esk Beds are significantly older than the Kholo Sub-Group, rather than earlier opinions, which favoured correlation of the Esk and Kholo sequences. It is also evident that deposition of the Esk and Ipswich sequences can be related to a major structure, the West Ipswich Structure (of Allen, Staines and Wilson, 1960, pp. 259, 260), which separates the two areas of sedimentation. The age determinations now available show that in the Middle Triassic the Esk Beds were laid down to the west of this structure, during an interval of non-deposition on its eastern side. After deposition of the Esk Beds, movement took place along the structure, so that the area to the west became a topographically high area and the Ipswich Coal Measures were then deposited on the eastern side, in Late Triassic time. Later still, the structure continued to influence the pattern of sedimentation, since while sediments of the Raceview Formation and Ripley Road Sandstone, over 1000 feet in total thickness, were being deposited on its eastern side, only an attenuated extension of the Raceview Formation, about 200 feet in thickness, was laid down on the western side (de Jersey, 1971a, p. 23).

Finally, it should be emphasised that the Middle Triassic age, here assigned to the Esk Beds, is based on material from the southern part of the Esk Trough, which extends over a length of at least 150 miles. Study of material from the Esk Beds in other parts of the trough will be necessary to determine whether they are of Middle Triassic age throughout their extent. In addition, study of material from units underlying the Esk Beds (the Neara Volcanics and Bryden Beds) is desirable to establish the time range of the complete Esk sequence.

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	GERMANIC GROUPS	ALPINE STAGES	BOWEN BASIN (Eastern Mimosa Syncline)	TARONG AREA	IPSWICH AREA	ESK TROUGH
LATE TRIASSIC	KEUPER	RHAETIAN			Ripley Rd. Sst.	
					Raceview Fmn.	
					Aberdare Cgl.	
		NORIAN				
		KARNIAN		Tarong Beds	Ipswich Coal Measures	
MIDDLE TRIASSIC		LADINIAN				
	MUSCHELKALK	ANISIAN	Moolayember Formation			Esk Beds
			Clematis Sandstone			
EARLY TRIASSIC	BUNTSANDSTEIN	SCYTHIAN	Rewan. Formation			

Figure 2– Showing ages of Esk Beds and other Triassic formations (based on miospore assemblages). Correlation of Germanic Groups and Alpine Stages based on Geiger and Hopping (1968).

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PLATE 1

(All photographs approximately × 1000)

Figure 1 —*Biretisporites* sp. A (median focus).

Figure 2 —*Calamospora tener* (Leschik) de Jersey, 1962 (median focus).

Figure 3 —*Clavatisporites* sp. cf. *C. hammenii* (Herbst) de Jersey, 1971 (equatorial focus).

Figure 4 —*Apiculatisporis clematisi* de Jersey, 1968 (median focus).

Figure 5 —*Uvaesporites verrucosus* (de Jersey) Helby, 1971 (median focus).

Figure 6 —*Cadargasporites* sp. (proximal focus).

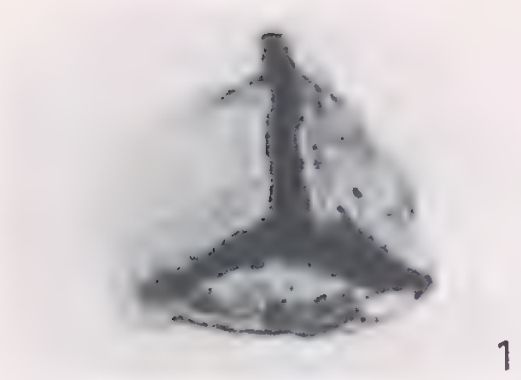
Figure 7 —*Converrucosisporites cameroni* (de Jersey) Playford & Dettmann, 1965 (equatorial focus).

Figure 8 —*Baculatisporites* sp. cf. *B. comaumensis* (Cookson) Potonié, 1956 (equatorial focus).

Figure 9 —*Lophotriletes novicus* Singh, 1964 (equatorial focus).

Figure 10—*Punctatisporites fungosus* Balme, 1963 (proximal focus).

Figure 11—*Neoraistrickia taylorii* Playford & Dettmann, 1965 (median focus).



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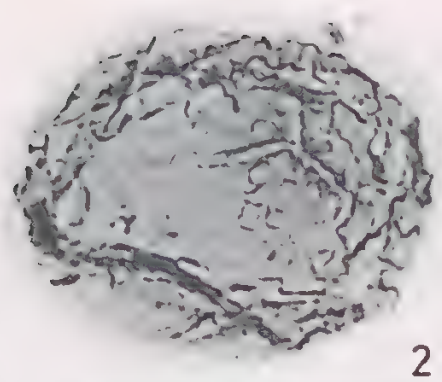

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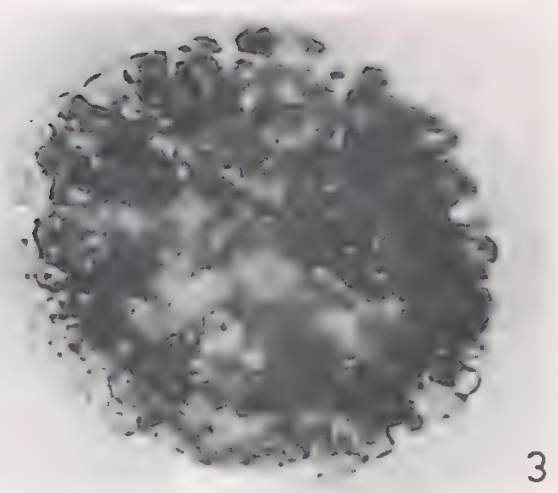

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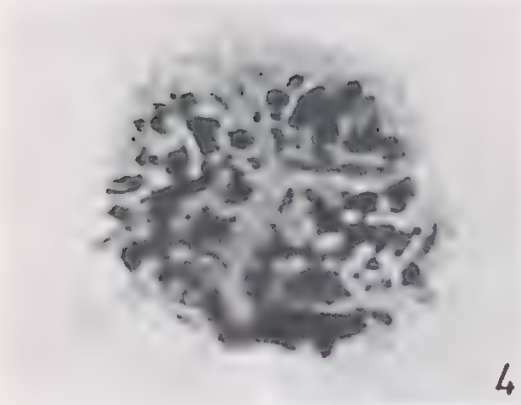

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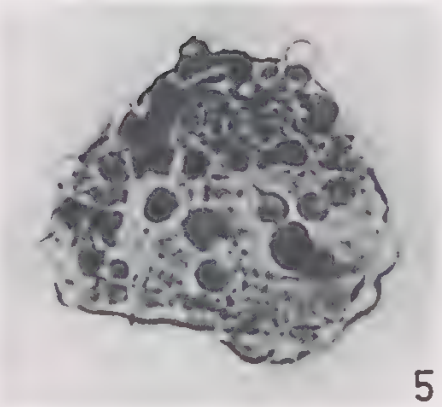

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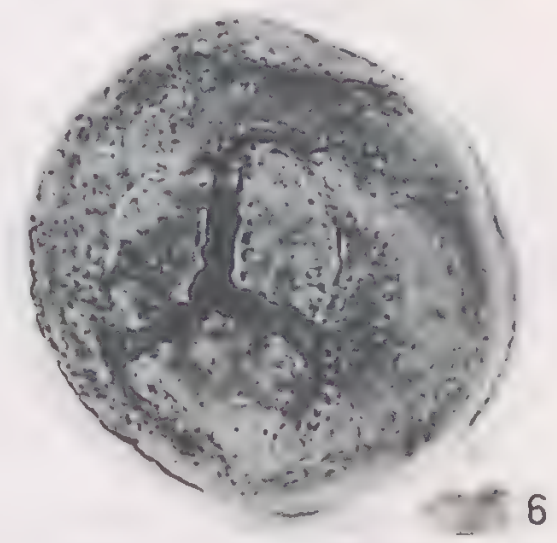

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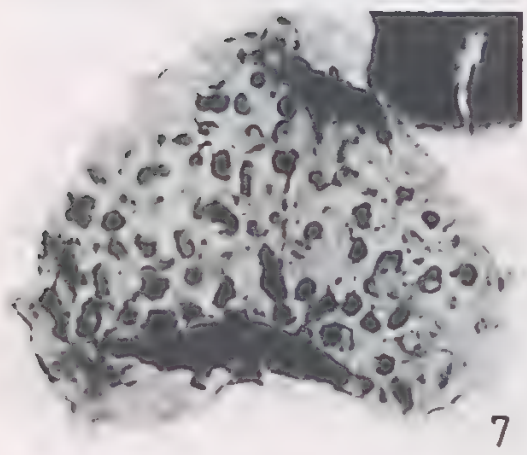

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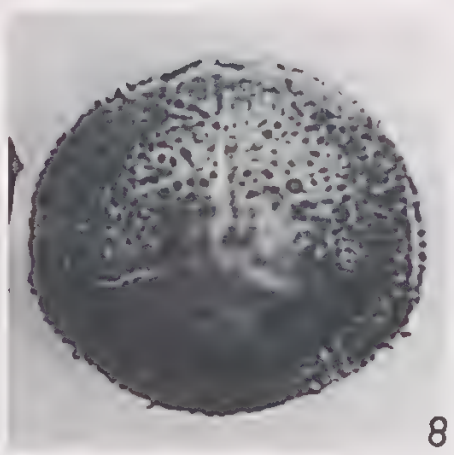

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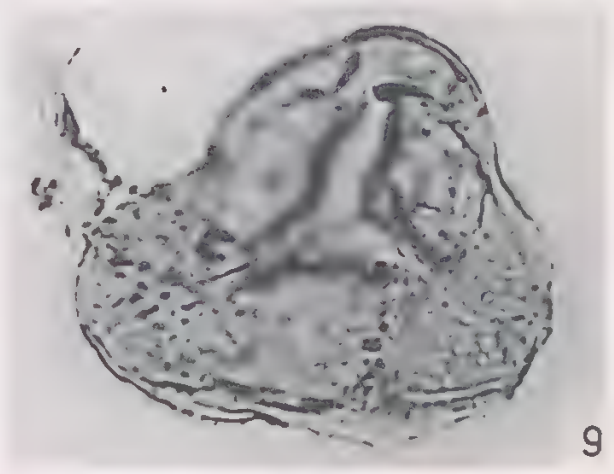

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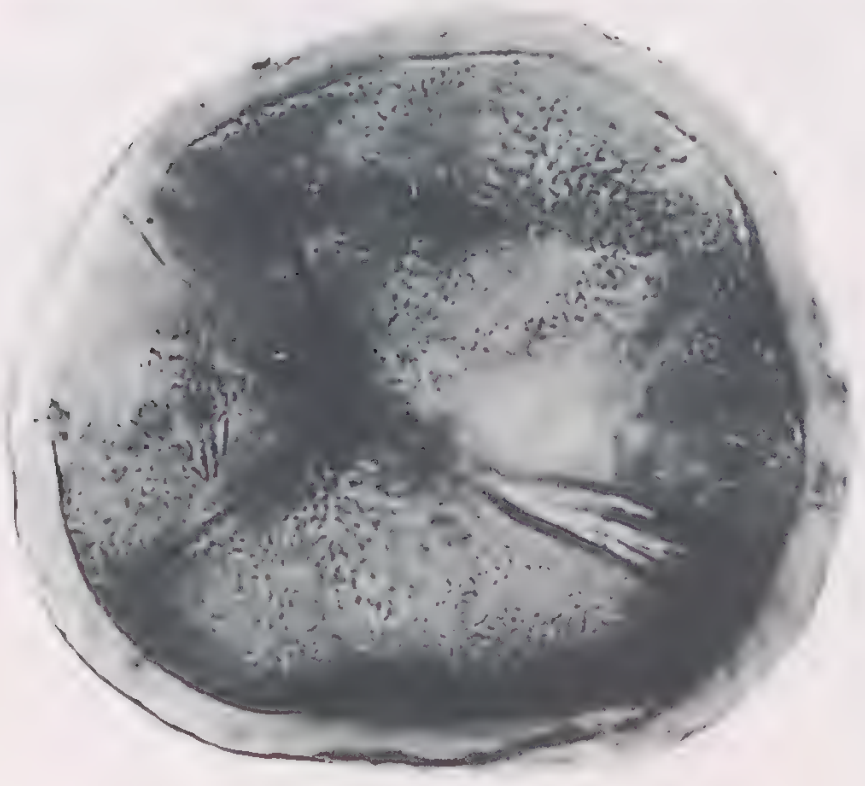

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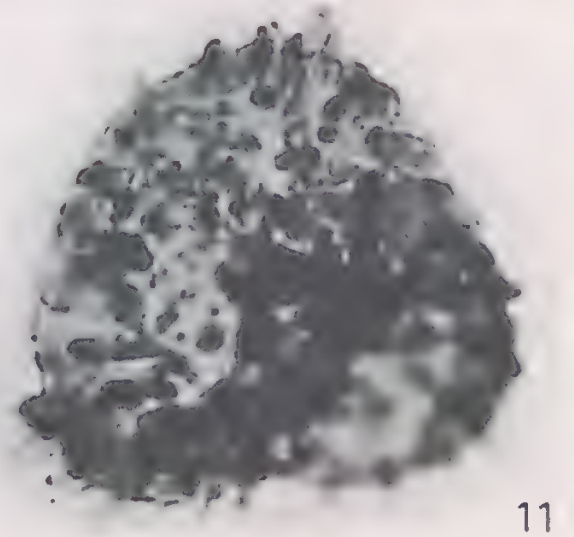

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PLATE 1

PLATE 2

(All photographs approximately × 1000)

Figure 1 —*Aratrisporites rugulatus* de Jersey, 1970 (median focus).

Figure 2 —*Aratrisporites paenulatus* Playford & Dettmann, 1965 (median focus).

Figure 3 —*Aratrisporites tenuispinosus* Playford, 1965 (equatorial focus).

Figure 4 —*Aratrisporites wollariensis* Helby, 1967 (median focus).

Figure 5 —*Aratrisporites strigosus* Playford, 1965 (lateral view, median focus).

Figure 6 —*Polypodiisporites ipsviciensis* (de Jersey) Playford & Dettmann, 1965 (proximal focus).

Figure 7 —*Densosporites raceviewensis* de Jersey, 1971 (median focus).

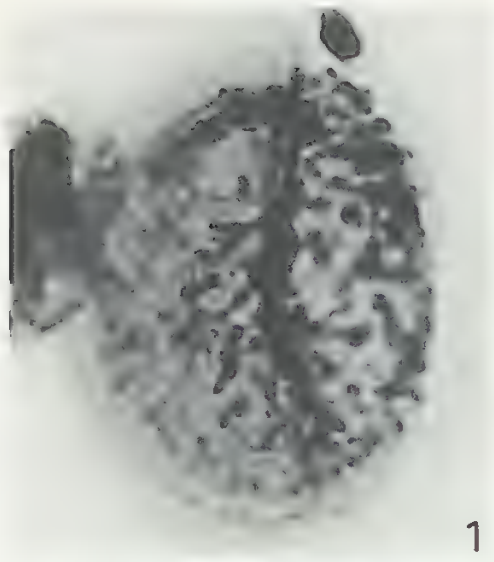
Figure 8 —*Densoisporites* sp. cf. *D. playfordi* (Balme) Dettmann, 1963 (median focus).

Figure 9 —*Punctatosporites walkomi* de Jersey, 1962 (median focus).

Fiture 10—*Indospora clara* Bharadwaj, 1962 (median focus).

Figure 11—*Aratrisporites banksi* Playford, 1965 (distal-equatorial focus).

Figure 12—*Rugulatisporites trisinus* de Jersey & Hamilton, 1967 (distal focus).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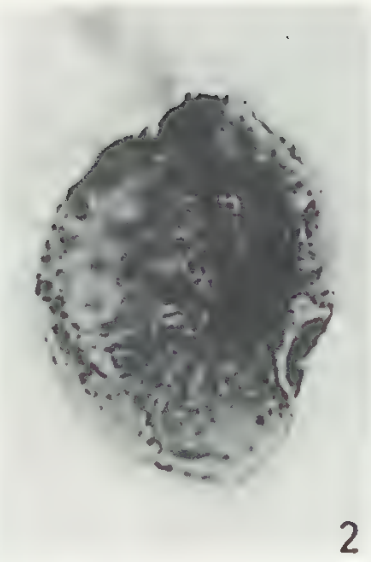
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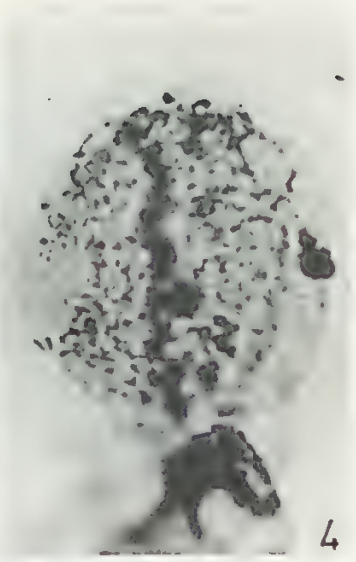
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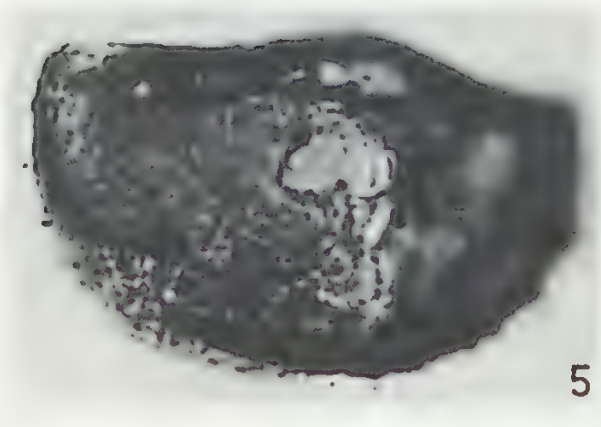
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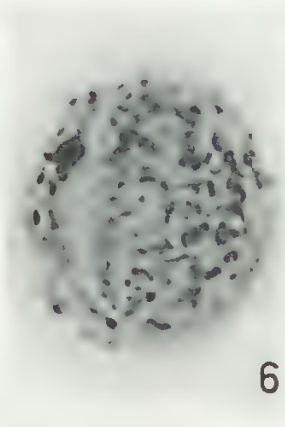
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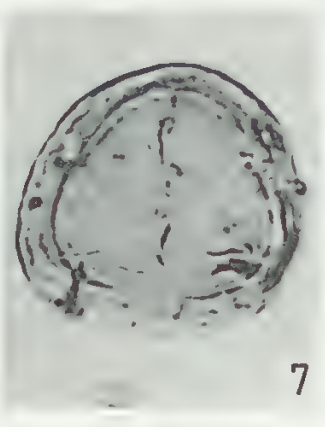
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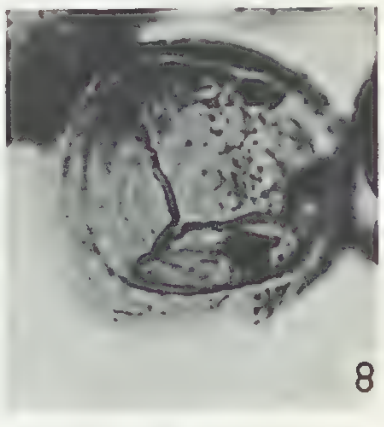
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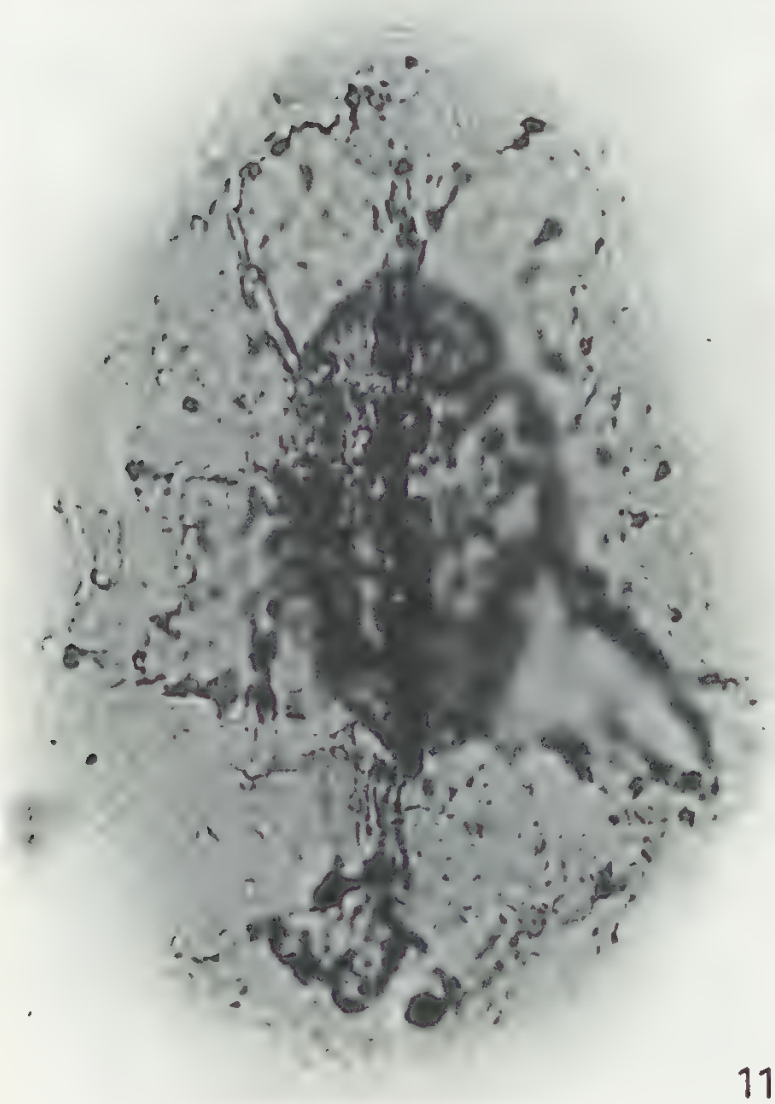
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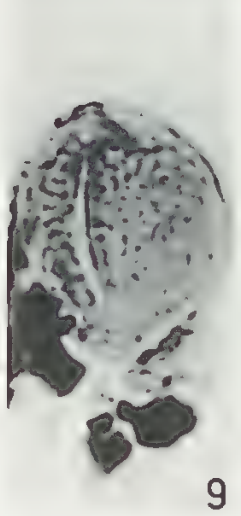
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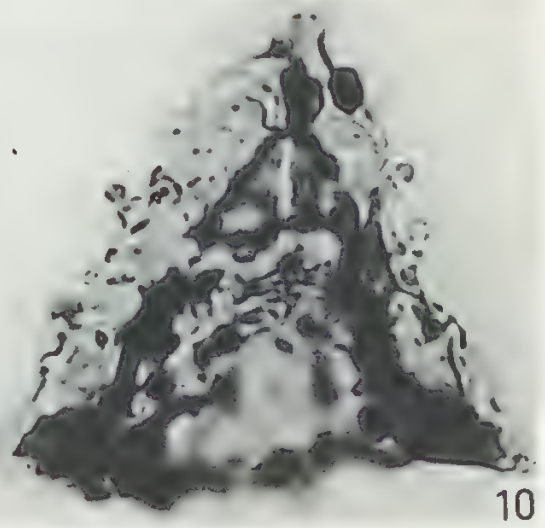
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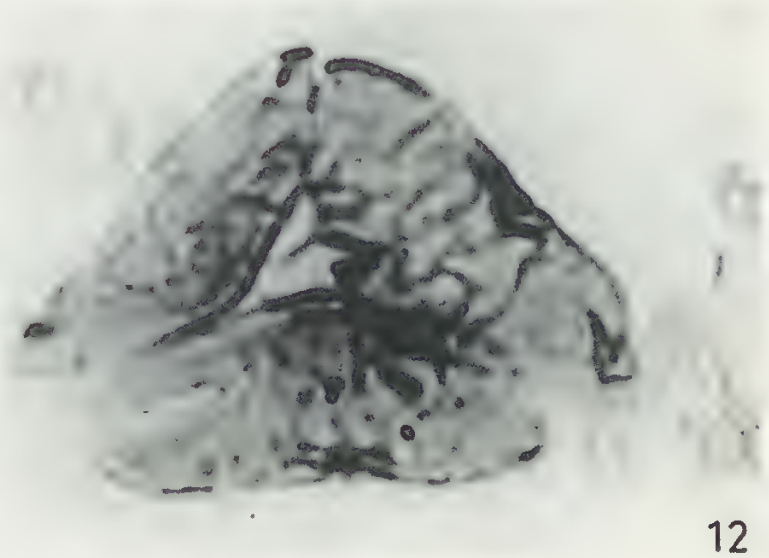
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PLATE 2

PLATE 3

(All photographs approximately × 1000)

Figure 1—*Duplexisporites problematicus* (Couper) Playford & Dettmann, 1965 (equatorial focus).

Figure 2—*Duplexisporites problematicus* (Couper) Playford & Dettmann, 1965 (equatorial focus).

Figure 3—*Accinctisporites ligatus* Leschik, 1955 (equatorial focus).

Figure 4—*Sulcosaccispora alaticonformis* (Malyavkina) de Jersey, 1968 (equatorial focus).

Figure 5—*Platysaccus queenslandi* de Jersey, 1962 (median focus).

Figure 6—*Accinctisporites ligatus* Leschik, 1955 (distal focus showing saccus attachment).

Figure 7—*Protodiploxypinus* sp. cf. *P. schizeatus* (Mädler) Scheuring, 1970 (median focus).

Figure 8—*Lueckisporites* sp. (proximal focus).

Figure 9—*Lunatisporites pellucidus* (Goubin) Helby, comb. nov. (proximal focus).

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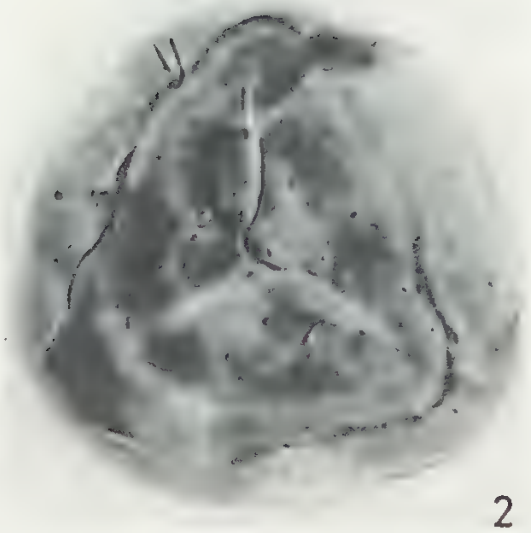

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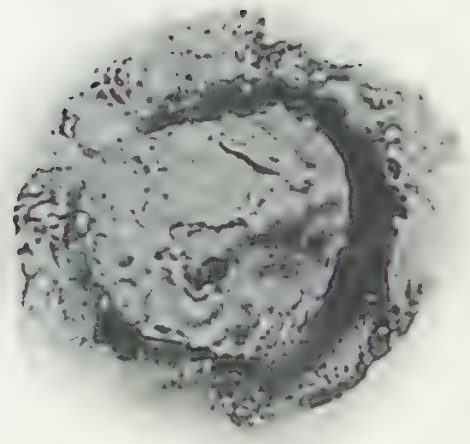

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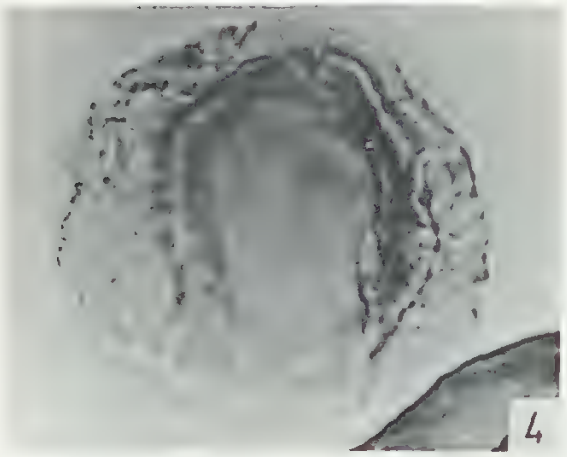

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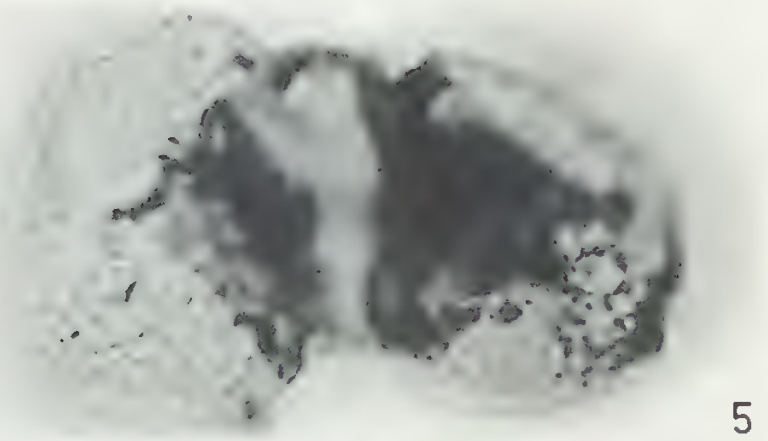

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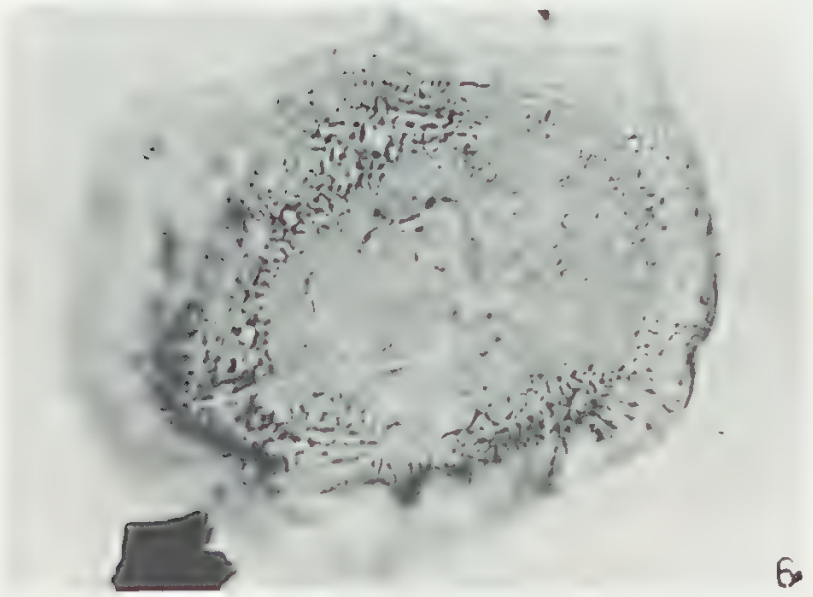

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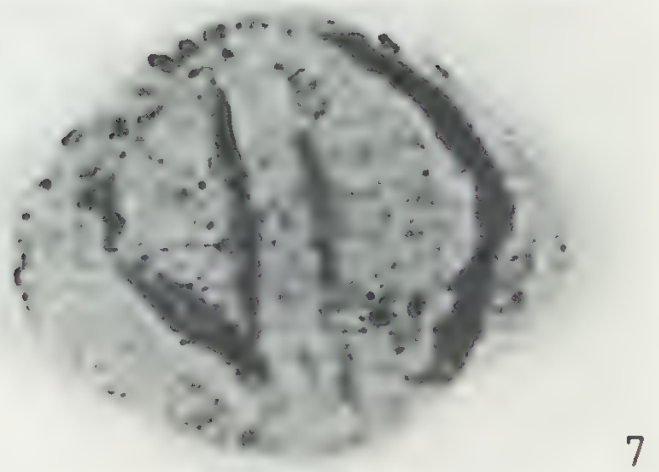

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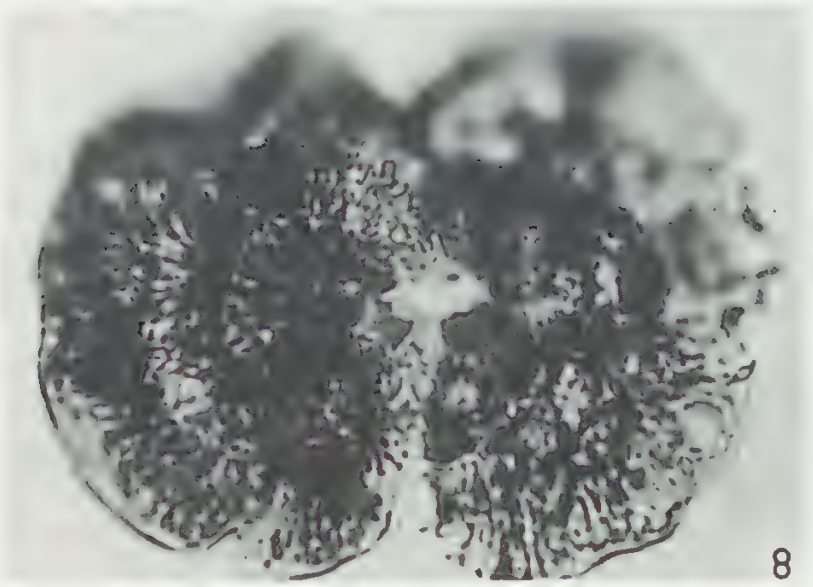

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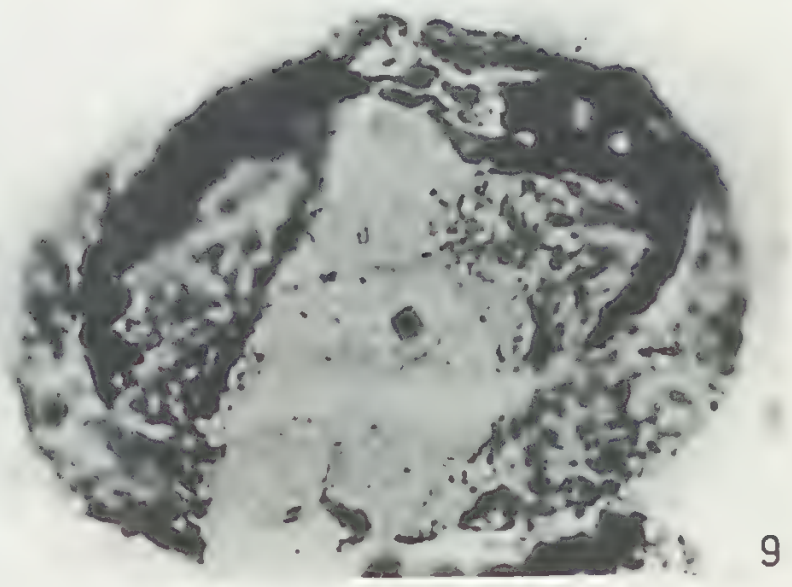

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PLATE 3

PLATE 4

(All photographs approximately × 1000, unless otherwise stated)

Figure 1—*Discisporites psilatus* de Jersey, 1964 (distal focus, showing rimula and adjacent folding).

Figure 2—*Grebespora concentrica* Jansonius, 1962 (median focus).

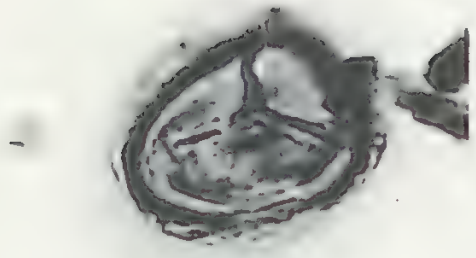
Figure 3—*Brachysaccus eskensis* sp. nov. (portion of specimen showing infrareticulum, × 1500).

Figure 4—*Brachysaccus eskensis* sp. nov. (Holotype, distal focus).

Figure 5—*Brachysaccus eskensis* sp. nov. (median focus; specimen showing splitting into two longitudinal portions, × 750).

Figure 6—*Voltziaceaesporites heteromorpha* Klaus, 1964 (median focus).

Figure 7—*Indusiisporites* sp. (distal focus).



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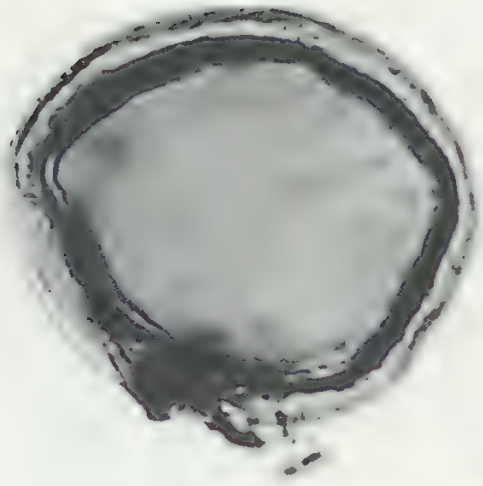

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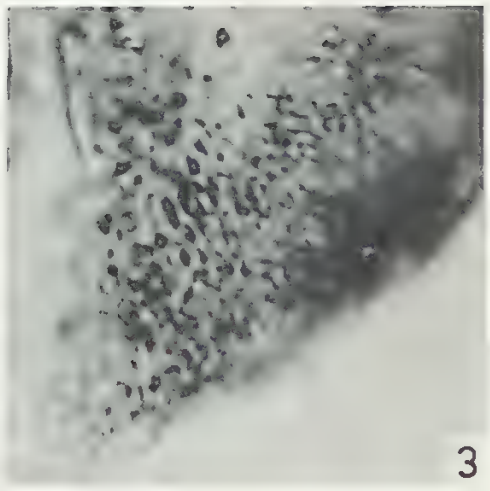

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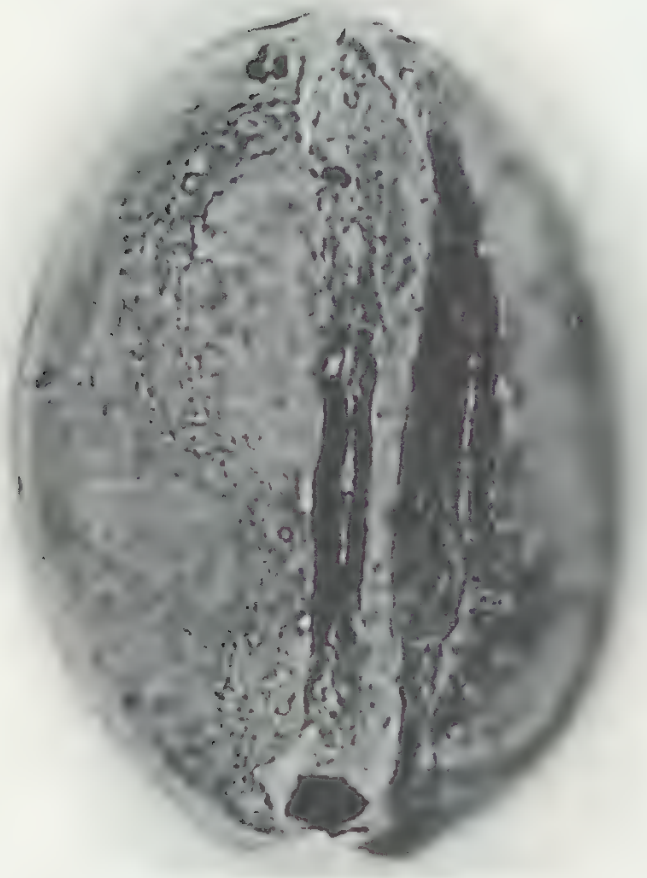

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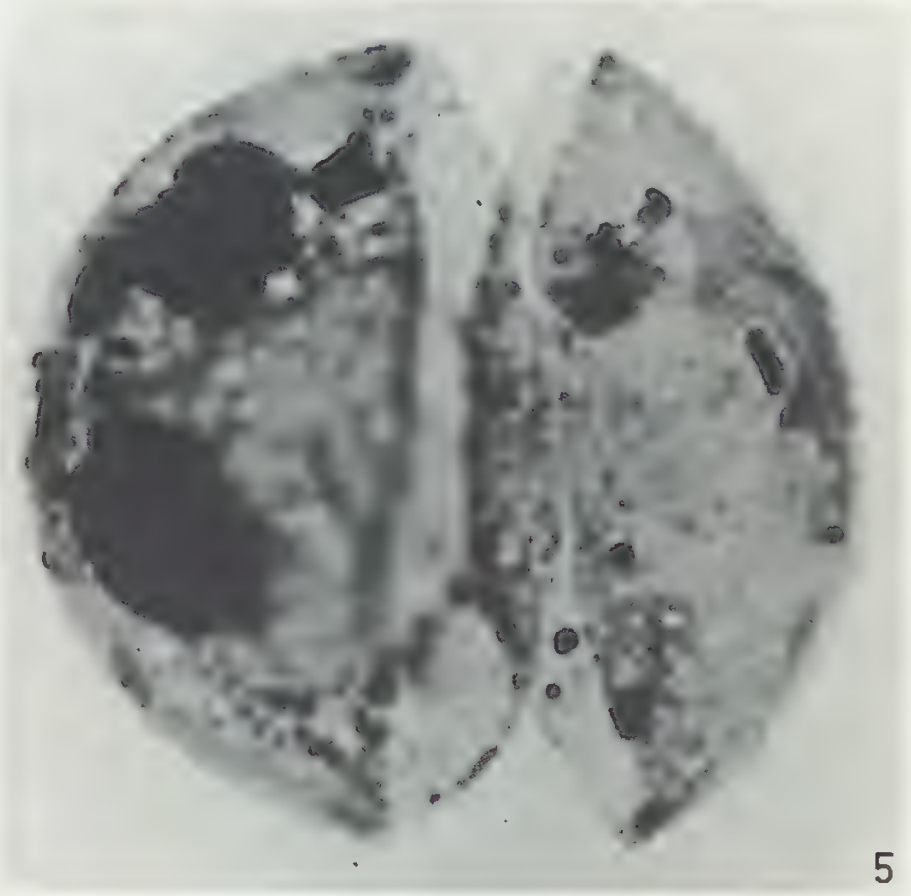

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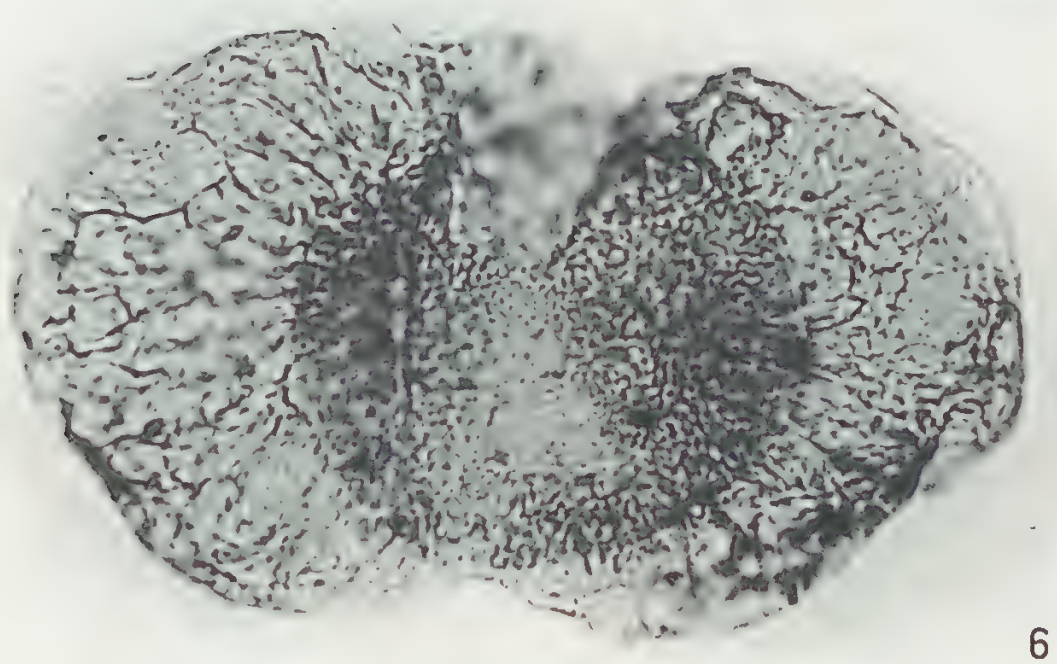

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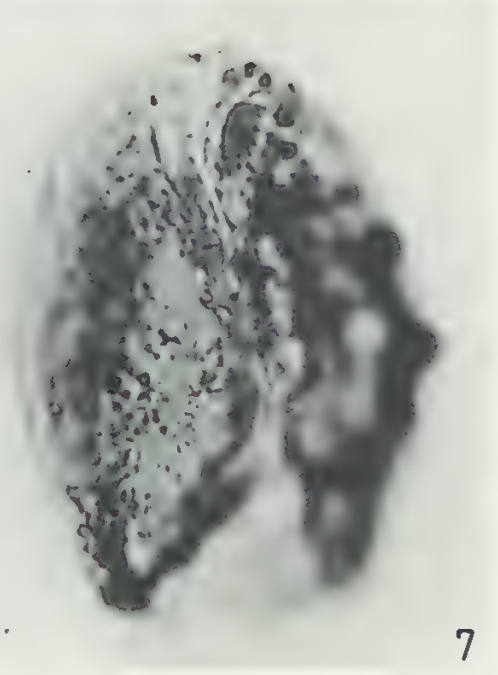

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PLATE 4

PLATE 5

(All photographs approximately × 1000)

Figure 1—*Equisetosporites steevesi* (Jansonius) de Jersey, 1968 (median focus, specimen with shrunken inner layer).

Figure 2—*Equisetosporites steevesi* (Jansonius) de Jersey, 1968 (equatorial focus).

Figure 3—*Veryhachium* sp. A (median focus, one spine broken off at base).

Figure 4—*Micrhystridium* sp. (median focus).

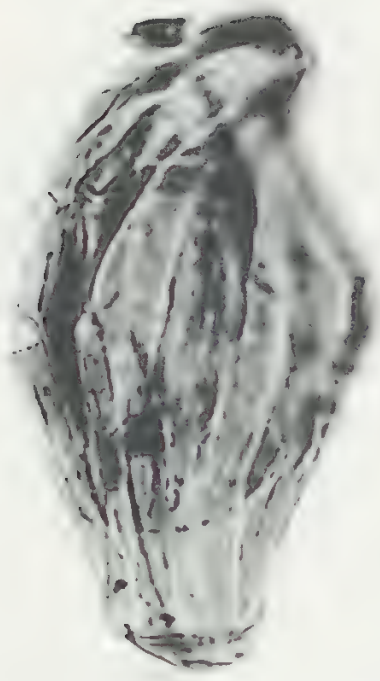
Figure 5—*Veryhachium valensii* (Valensi) emend. Downie & Sarjeant, 1964 (median focus).

Figure 6—*Pilasporites crateraformis* Jain, 1968 (median focus).

Figure 7—*Cycadopites* sp. cf. *C. potoniei* Bharadwaj & Singh, 1964 (distal-equatorial focus).

Figure 8—*Cycadopites nitidus* (Balme) de Jersey, 1964 (distal-equatorial focus).

Figure 9—*Pilasporites* sp. A (median focus).



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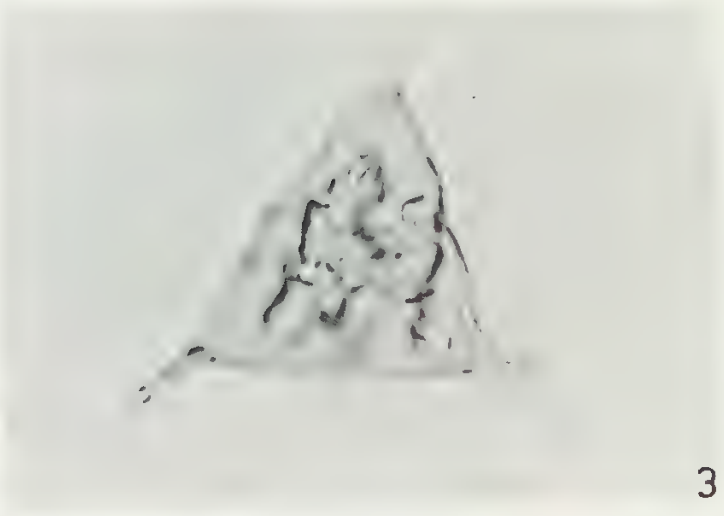

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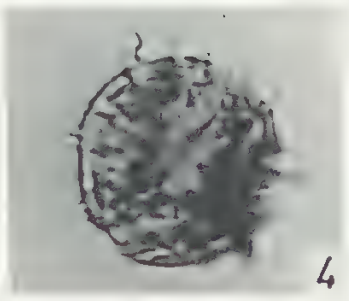

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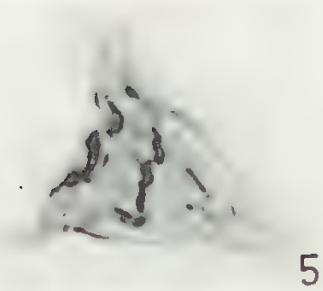

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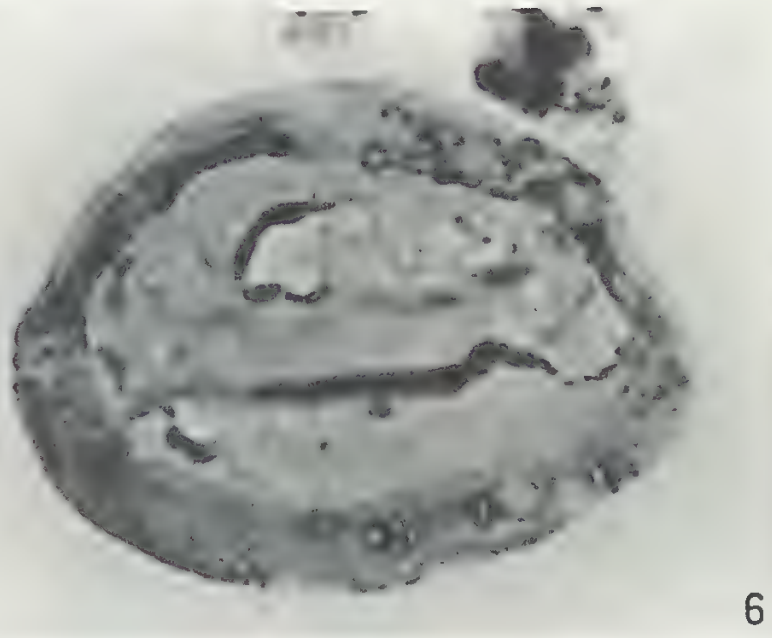

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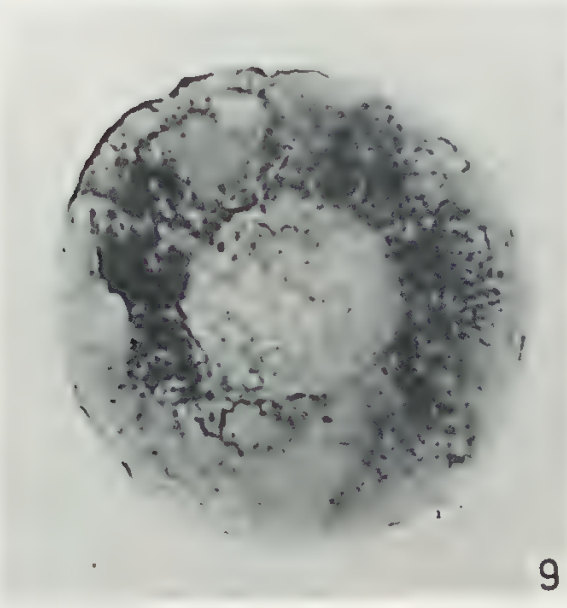

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PLATE 5

APPENDIX — Lists of Microfloral Assemblages

The assemblages recorded below are arranged in ascending stratigraphic order, for each of the boreholes studied. In the headings for the samples, depth, lithology, formation and number of specimens are recorded. Regarding the latter, the figures indicate that counts of these magnitudes were made; addition of the + sign, e.g. 200 +, indicates that an additional low power traverse was made of the available slides. Species recorded only in such additional traverses are indicated by the sign + in each list. Indeterminate specimens have not been included.

G.S.Q. IPSWICH 17

ESK BEDS

2921 ft. 1 in.

Shale

No count

Acanthotriletes sp.
Alisporites spp.
Apiculatisporis sp. (indet.)
Cycadopites crassimarginis
Cycadopites nitidus
Densoisporites sp.
Grebespora concentrica
Inaperturopollenites sp.
Leiotriletes directus
Lophotriletes sp.
Neoraistrickia taylorii
Osmundacidites sp.
Polypodiisporites ipsviciensis
Protohaploxypinus sp.
Stereisporites sp.
Striate monosaccate pollen (indet.)

2885 ft. 3 in.

Shale

Count 200 +

Accinctisporites ligatus	0.5%
Alisporites spp.	63.5%
Aratrisporites strigosus	+
Araucariacites spp.	4.0%
Baculatisporites sp.	+
Calamospora tener	1.0%
Chordasporites australiensis	0.5%
Chordasporites sp. (indet.)	1.0%
Clavatisporites cf. *hammenii*	2.5%
Conaletes spp.	1.5%
Cycadopites nitidus	2.5%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	1.0%
Discisporites psilatus	1.0%
Duplexisporites problematicus	+
Equisetosporites steevesi	+
Guttatisporites visscheri	1.0%
Inaperturopollenites spp.	12.0%
Leiotriletes directus	1.0%
Neoraistrickia taylorii	0.5%
Osmundacidites spp.	1.5%
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	1.0%
Punctatisporites sp.	0.5%
Retusotriletes junior	+
Rugulatisporites trisinus	0.5%
Verrucosisporites spp.	1.0%
Striatites (indet.)	+

2858 ft. 5 in.

Shale

Count 200 +

Alisporites spp.	19.0%
Apiculatisporis sp. (indet.)	0.5%
Aratrisporites wollariensis	0.5%
Araucariacites spp.	6.5%
Baculatisporites cf. *comaumensis*	0.5%
Biretisporites sp.	1.0%
Clavatisporites cf. *hammenii*	1.0%
Conaletes spp.	1.0%
Converrucosisporites cameroni	1.5%
Converrucosisporites sp. (indet.)	0.5%
Cyathidites sp. (indet.)	+
Cycadopites crassimarginis	0.5%
Cycadopites granulatus	0.5%
Cycadopites nitidus	3.0%
Densoisporites sp.	0.5%
Dictyophyllidites mortoni	1.0%
Dictyophyllidites sp. (indet.)	0.5%
Discisporites psilatus	0.5%
Duplexisporites problematicus	1.5%
? *Hamiapollenites insculptus*	0.5%
Inaperturopollenites spp.	24.0%
Indusiisporites sp.	+
Leiotriletes directus	5.5%
Leiotriletes sp. (indet.)	0.5%
Lophotriletes sp. (indet.)	1.5%
Osmundacidites spp.	9 0%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	11.5%
Protohaploxypinus sp.	0.5%
Punctatisporites sp. (indet.)	1.5%
Punctatosporites walkomi	2.0%
Retusotriletes junior	+
Rugulatisporites sp.	+
Stereisporites sp. (indet.)	1.0%
Sulcosaccispora alaticonformis	+
Uvaesporites verrucosus	+
Verrucosisporites spp.	1.0%
Vitreisporites pallidus	0.5%
Striatites (indet.)	0.5%
Acritarch (*Veryhachium valensii*)	0.5%

2841 ft. 4 in.

Greenish grey shale

Count 200 +

Alisporites spp.	29.5%
Apiculatisporis sp. (indet.)	1.5%
Aratrisporites sp. (indet.)	+
Araucariacites sp. (indet.)	0.5%
Chordasporites sp. (indet.)	+
Clavatisporites cf. *hammenii*	1.0%
Clavatisporites sp. (indet.)	0.5%
Cycadopites nitidus	3.0%
Dictyophyllidites harrisii	+
Dictyophyllidites mortoni	2.5%
Granulatisporites sp.	0.5%
Inaperturopollenites spp.	8.5%
Indusiisporites sp. (indet.)	1.5%
Leiotriletes directus	0.5%
Leiotriletes sp. (indet.)	0.5%
Lophotriletes sp.	0.5%
Osmundacidites spp.	8.0%
Polypodiisporites ipsviciensis	0.5%
Punctatisporites sp.	40.0%
Stereisporites sp.	0.5%
Uvaesporites verrucosus	0.5%

2714 ft. 2 in.

Greenish grey shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	11.0%
Apiculatisporis clematisi	+
Aratrisporites strigosus	+
Aratrisporites tenuispinosus	0.5%

Aratrisporites wollariensis	+
Araucariacites spp.	3.5%
Calamospora sp. (indet.)	0.5%
Chordasporites sp. (indet.)	+
Clavatisporites cf. *hammenii*	1.0%
Cyathidites cf. *breviradiatus*	0.5%
Cyathidites sp. (indet.)	+
Cycadopites nitidus	3.0%
Cycadopites cf. *potoniei*	+
Densoisporites sp.	+
cf. *Densoisporites* sp.	+
Dictyophyllidites mortoni	0.5%
cf. *Discisporites psilatus*	+
Duplexisporites problematicus	+
Grebespora concentrica	0.5%
Inaperturopollenites spp.	53.5%
Leiotriletes directus	6.0%
Leiotriletes sp. (indet.)	0.5%
Lophotriletes sp. (indet.)	0.5%
Lunatisporites sp. (indet.)	+
Neoraistrickia taylorii	0.5%
Osmundacidites spp.	6.0%
Polypodiisporites ipsviciensis	5.5%
Punctatisporites spp.	4.0%
Punctatosporites walkomi	0.5%
Stereisporites spp.	2.0%
Uvaesporites verrucosus	+
cf. *Verrucosisporites* sp.	+
Vitreisporites pallidus	+
Acritarch (*Veryhachium* sp. A)	+

2631 ft.

Greenish grey shale

Count 100 +

Alisporites spp.	41.0%
Aratrisporites sp. (indet.)	+
Araucariacites sp.	1.0%
Cycadopites nitidus	7.0%
Dictyophyllidites mortoni	2.0%
Discisporites psilatus	+
Duplexisporites problematicus	+
Inaperturopollenites spp.	6.0%
Indusiisporites sp.	+
Leiotriletes directus	8.0%
Lophotriletes sp.	+
Neoraistrickia sp. (indet.)	1.0%
Osmundacidites sp.	1.0%
Polypodiisporites ipsviciensis	33.0%
Stereisporites sp.	+
Uvaesporites verrucosus	+

2474 ft. 6 in.

Dark grey shale

Count 200 +

Alisporites spp.	41.5%
Apiculatisporis sp. (indet.)	2.0%
Aratrisporites paenulatus	+
Aratrisporites strigosus	0.5%
Araucariacites spp.	1.5%
cf. *Brachysaccus* sp.	+
Chordasporites sp. (indet.)	+
cf. *Chordasporites* sp.	+
Conaletes sp.	0.5%
Converrucosisporites cameroni	2.5%
Converrucosisporites sp. (indet.)	0.5%
Cycadopites granulatus	0.5%
Cycadopites nitidus	2.5%
Cycadopites sp. (indet.)	1.0%
Dictyophyllidites mortoni	6.5%
Duplexisporites problematicus	+
Equisetosporites steevesi	+
Foveosporites mimosae	+
Foveosporites sp.	0.5%
Granulatisporites sp.	0.5%
Inaperturopollenites spp.	14.0%
Indusiisporites spp.	+
Leiotriletes directus	8.5%
Leiotriletes sp. (indet.)	0.5%
Lophotriletes novicus	0.5%
Lunatisporites sp. (indet.)	+
cf. *Lunatisporites* sp.	+
Neoraistrickia taylorii	1.0%
Neoraistrickia sp.	0.5%
Osmundacidites spp.	4.5%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	6.0%
Protohaploxypinus sp. (indet.)	0.5%
Punctatosporites walkomi	0.5%
Stereisporites sp. (indet.)	1.0%
Striatoabietites sp. (indet.)	+
Sulcosaccispora alaticonformis	0.5%
Tuberculatosporites aberdarensis	0.5%
Striatites (indet.)	1.0%

2387 ft. 6 in.

Dark grey shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	63.5%
Apiculatisporis sp. (indet.)	0.5%
Aratrisporites banksi	1.5%
Aratrisporites rugulatus	+
Aratrisporites strigosus	0.5%
Araucariacites spp.	8.0%
Brachysaccus eskensis	+
Cadargasporites sp.	+
Conaletes sp.	0.5%
Converrucosisporites cameroni	+
Cyathidites sp. (indet.)	0.5%
Cycadopites crassimarginis	0.5%
Cycadopites nitidus	1.5%
Dictyophyllidites mortoni	0.5%
Duplexisporites problematicus	+
Granulatisporites sp.	0.5%
Inaperturopollenites spp.	16.0%
Indusiisporites sp.	+
Leiotriletes directus	2.0%
Lophotriletes novicus	+
Neoraistrickia taylorii	+
Osmundacidites spp.	1.0%
Pilasporites sp. A	+
Platysaccus queenslandi	1.0%
Polypodiisporites ipsviciensis	0.5%
Protodiploxypinus cf. *schizeatus*	+
Stereisporites sp.	0.5%
Sulcosaccispora alaticonformis	0.5%
Voltziaceaesporites heteromorpha	0.5%
Striatites (indet.)	+

2233 ft. 3 in.

Greenish grey shale

No count

Alisporites spp.
Apiculatisporis clematisi
Aratrisporites strigosus
Converrucosisporites sp.
Cycadopites nitidus
cf. *Discisporites psilatus*
Equisetosporites steevesi
Osmundacidites sp.
Polypodiisporites ipsviciensis
Verrucosisporites sp.
Vitreisporites pallidus

1994 ft. 6 in.

Greenish grey shale

Count 200 +

Alisporites spp.	10.0%
Apiculatisporis sp. (indet.)	3.0%

Araucariacites spp.	2.0%
Biretisporites sp. A	0.5%
Brachysaccus eskensis	+
Chordasporites sp. (indet.)	0.5%
Clavatisporites sp.	+
Converrucosisporites cameroni	0.5%
Converrucosisporites sp. (indet.)	0.5%
Cyathidites sp. (indet.)	+
Cycadopites nitidus	10.0%
Densosporites raceviewensis	0.5%
Dictyophyllidites mortoni	1.0%
Discisporites psilatus	1.0%
Duplexisporites problematicus	+
Guttatisporites visscheri	1.0%
Inaperturopollenites spp.	7.5%
Indusiisporites sp.	+
Kraeuselisporites saeptatus	+
Leiotriletes directus	7.0%
Lophotriletes sp. (indet.)	2.5%
Neoraistrickia sp. (indet.)	1.0%
Osmundacidites spp.	6.5%
Polypodiisporites ipsviciensis	43.5%
cf. *Retusotriletes* sp.	0.5%
Stereisporites sp.	0.5%
Uvaesporites verrucosus	0.5%

1863 ft. 2 in.

Dark greenish grey shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	24.5%
Apiculatisporis sp. (indet.)	1.0%
Baculatisporites cf. *comaumensis*	+
Biretisporites sp. A	+
Chordasporites sp. (indet.)	+
Clavatisporites cf. *hammenii*	1.0%
Converrucosisporites spp.	1.0%
Cycadopites crassimarginis	+
Cycadopites granulatus	0.5%
Cycadopites nitidus	5.0%
Cycadopites sp. (indet.)	0.5%
Densoisporites cf. *playfordi*	+
Densosporites raceviewensis	+
Densosporites sp.	+
cf. *Densosporites* sp.	0.5%
Dictyophyllidites mortoni	1.0%
Discisporites psilatus	+
Duplexisporites problematicus	0.5%
cf. *Endosporites* sp.	+
Equisetosporites steevesi	+
Equisetosporites sp.	1.0%
Foveosporites sp.	+
Inaperturopollenites spp.	4.5%
Indusiisporites sp.	1.0%
Laevigatosporites sp.	+
Leiotriletes directus	3.5%
Lophotriletes sp.	0.5%
Lunatisporites sp. (indet.)	0.5%
Neoraistrickia cf. *taylorii*	0.5%
Osmundacidites spp.	9.0%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	31.5%
Punctatosporites walkomi	7.0%
cf. *Retusotriletes* sp.	+
Stereisporites sp. (indet.)	1.0%
Sulcosaccispora alaticonformis	+
Tuberculatosporites aberdarensis	0.5%
Uvaesporites verrucosus	3.0%
cf. *Uvaesporites verrucosus*	+
Verrucosisporites sp.	1.0%
Vitreisporites pallidus	+

1820 ft. 2 in.

Dark grey shale

Count 200 +

Alisporites spp.	19.0%
Apiculatisporis sp. (indet.)	1.0%
Aratrisporites banksi	+
Aratrisporites paenulatus	+
Aratrisporites strigosus	1.0%
Aratrisporites sp.	+
Araucariacites spp.	1.0%
Calamospora tener	0.5%
Conaletes spp.	1.5%
Conbaculatisporites sp.	0.5%
Converrucosisporites cameroni	0.5%
Cycadopites granulatus	1.0%
Cycadopites nitidus	4.5%
Cycadopites sp. (indet.)	+
Densoisporites sp.	0.5%
Densosporites raceviewensis	+
Dictyophyllidites mortoni	5.0%
Dictyophyllidites sp. (indet.)	0.5%
Discisporites psilatus	1.0%
Duplexisporites problematicus	+
Foveosporites sp.	0.5%
Granulatisporites spp.	4.5%
Grebespora concentrica	+
Guthoerlisporites cancellosus	+
Inaperturopollenites spp.	9.5%
Indusiisporites sp.	1.0%
Leiotriletes directus	10.0%
Lophotriletes sp.	1.0%
Lunatisporites sp.	+
Osmundacidites spp.	6.0%
Polypodiisporites ipsviciensis	24.0%
Punctatisporites spp.	2.0%
Punctatosporites walkomi	1.5%
Sulcosaccispora alaticonformis	+
Uvaesporites verrucosus	2.0%
cf. *Uvaesporites verrucosus*	+
Verrucosisporites sp.	0.5%

1661 ft. 2 in.

Greenish grey shale

Count 200 +

Accinctisporites ligatus	0.5%
Alisporites spp.	26.5%
Apiculatisporis sp. (indet.)	0.5%
Araucariacites spp.	1.5%
Chordasporites australiensis	+
Conaletes sp.	+
Converrucosisporites cameroni	+
Cycadopites crassimarginis	0.5%
Cycadopites nitidus	7.0%
Densoisporites sp. (indet.)	0.5%
Densosporites raceviewensis	+
Dictyophyllidites mortoni	1.0%
Discisporites psilatus	0.5%
Duplexisporites problematicus	2.0%
Equisetosporites sp. (indet.)	0.5%
Granulatisporites sp.	0.5%
Guttatisporites visscheri	+
Inaperturopollenites spp.	11.5%
Leiotriletes directus	2.0%
Leiotriletes sp. (indet.)	0.5%
Neoraistrickia taylorii	+
Osmundacidites spp.	15.0%
Polypodiisporites ipsviciensis	22.0%
Punctatosporites walkomi	0.5%
Rugulatisporites trisinus	+
Stereisporites sp.	0.5%
Uvaesporites verrucosus	4.5%
cf. *Uvaesporites verrucosus*	1.0%
Verrucosisporites spp.	1.5%
Voltziaceaesporites heteromorpha	+

1588 ft. 11 in.

Greenish grey siltstone

Count 200 +

Alisporites spp.	16.5%
Apiculatisporis clematisi	+
Apiculatisporis sp. (indet.)	0.5%

Aratrisporites strigosus	+
Araucariacites spp.	2.0%
Calamospora tener	+
Conaletes spp. (indet.)	1.5%
Conbaculatisporites sp.	0.5%
Converrucosisporites cameroni	+
Cycadopites granulatus	0.5%
Cycadopites nitidus	9.0%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	1.0%
Discisporites psilatus	+
Duplexisporites problematicus	+
Foveosporites sp. (indet.)	1.0%
Granulatisporites sp.	0.5%
Grebespora concentrica	+
Grebespora cf. *concentrica*	0.5%
Guttatisporites visscheri	+
Inaperturopollenites spp.	21.5%
Indusiisporites sp.	0.5%
Leiotriletes directus	10.0%
Lophotriletes novicus	+
Lophotriletes spp. (indet.)	3.0%
Neoraistrickia taylorii	+
Neoraistrickia cf. *taylorii*	+
Osmundacidites spp.	8.5%
Polypodiisporites ipsviciensis	16.0%
Punctatisporites sp.	0.5%
Rugulatisporites sp.	0.5%
Stereisporites sp. (indet.)	1.0%
Sulcosaccispora alaticonformis	0.5%
Tuberculatosporites aberdarensis	0.5%
Uvaesporites verrucosus	2.5%
Verrucosisporites sp.	1.0%

1542 ft. 8 in.

Greenish grey shale

No count

Aratrisporites strigosus
Conaletes sp.
Converrucosisporites sp.
Cycadopites nitidus
Densosporites raceviewensis
Dictyophyllidites mortoni
Duplexisporites problematicus
Inaperturopollenites sp.
Leiotriletes directus
Lophotriletes sp.
Osmundacidites sp.
Polypodiisporites ipsviciensis
Punctatosporites walkomi
Stereisporites sp.

1459 ft. 11 in.

Greenish grey shale

Count 200 +

Alisporites spp.	5.5%
Apiculatisporis clematisi	2.0%
Apiculatisporis sp. (indet.)	1.0%
Araucariacites spp.	2.5%
Clavatisporites cf. *hammenii*	5.0%
Converrucosisporites cameroni	+
Cycadopites nitidus	4.5%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	2.5%
Duplexisporites problematicus	2.5%
Granulatisporites sp. (indet.)	1.5%
Inaperturopollenites spp.	11.5%
Leiotriletes directus	9.5%
Lophotriletes spp.	1.0%
cf. *Marsupipollenites* sp.	+
Neoraistrickia cf. *taylorii*	1.0%
Osmundacidites spp.	9.5%
Polypodiisporites ipsviciensis	34 5%
Punctatisporites sp.	1.0%
Punctatosporites walkomi	0.5%
Sulcosaccispora alaticonformis	0.5%
Uvaesporites verrucosus	1.5%
Verrucosisporites spp.	2.5%

1434 ft. 8 in.

Greenish grey shale

No count

Alisporites spp.
Apiculatisporis clematisi
Dictyophyllidites mortoni
Duplexisporites problematicus
Granulatisporites sp.
Inaperturopollenites sp.
Leiotriletes directus
Osmundacidites sp.
Polypodiisporites ipsviciensis
Uvaesporites verrucosus
Striatites (indet.)

1255 ft. 7 in.

Greenish grey shale

No count

Alisporites spp.
Calamospora tener
Cycadopites nitidus
Inaperturopollenites sp.
Leiotriletes directus
Osmundacidites sp.
Polypodiisporites ipsviciensis
Uvaesporites verrucosus

1203 ft. 9 in.

Greenish grey shale

Count 100 +

Accinctisporites ligatus	+
Alisporites spp.	62.0%
Aratrisporites strigosus	7.0%
Calamospora tener	2.0%
Clavatisporites cf. *hammenii*	+
Conaletes sp.	2.0%
Converrucosisporites cameroni	+
Converrucosisporites sp. (indet.)	1.0%
Cycadopites nitidus	2.0%
Cycadopites sp. (indet.)	1.0%
cf. *Densoisporites* sp.	1.0%
Dictyophyllidites mortoni	+
Duplexisporites problematicus	+
Grebespora concentrica	+
Inaperturopollenites spp.	5.0%
cf. *Indusiisporites* sp.	+
Leiotriletes directus	3.0%
Lophotriletes sp.	+
Lueckisporites sp.	+
Osmundacidites spp.	6.0%
Polypodiisporites ipsviciensis	3.0%
Punctatosporites walkomi	+
Stereisporites sp. (indet.)	1.0%
Sulcosaccispora alaticonformis	2.0%
Uvaesporites verrucosus	+
Vitreisporites sp. (indet.)	1.0%
? Acritarch	1.0%

1158 ft. 9 in.

Grey mudstone

No count

Alisporites spp.
Araucariacites sp.
Cycadopites nitidus
Dictyophyllidites mortoni
Leiotriletes directus

Neoraistrickia taylorii
Osmundacidites sp.
Polypodiisporites ipsviciensis
Punctatosporites walkomi
Stereisporites sp.
Uvaesporites verrucosus

1086 ft. 1 in.

Greenish grey shale

No count

Alisporites spp.
Clavatisporites cf. *hammenii*
Converrucosisporites cameroni
Cycadopites nitidus
Cycadopites sp. (indet.)
Dictyophyllidites mortoni
Granulatisporites sp.
Inaperturopollenites sp.
Indospora sp.
Leiotriletes directus
Neoraistrickia sp.
Osmundacidites sp.
Polypodiisporites ipsviciensis
Sulcosaccispora alaticonformis
Uvaesporites verrucosus

876 ft. 5 in.

Greenish grey shale

Count 200 +

Alisporites spp.	42.0%
Apiculatisporis clematisi	+
Apiculatisporis sp. (indet.)	2.0%
Araucariacites spp.	2.5%
Baculatisporites cf. *comaumensis*	0.5%
Chordasporites sp. (indet.)	0.5%
Clavatisporites cf. *hammenii*	1.5%
Converrucosisporites cameroni	1.0%
Converrucosisporites sp. (indet.)	0.5%
Cycadopites crassimarginis	0.5%
Cycadopites granulatus	+
Cycadopites nitidus	8.0%
Densoisporites sp.	0.5%
Dictyophyllidites mortoni	2.0%
Discisporites psilatus	+
Duplexisporites problematicus	1.0%
Equisetosporites steevesi	0.5%
Granulatisporites sp.	0.5%
Grebespora concentrica	+
Guttatisporites visscheri	1.0%
Inaperturopollenites spp.	7.5%
Indospora clara	+
Leiotriletes directus	7.5%
Lophotriletes sp.	0.5%
Osmundacidites spp.	4.5%
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	11.5%
Stereisporites sp. (indet.)	0.5%
Sulcosaccispora alaticonformis	+
Uvaesporites verrucosus	2.5%
Vitreisporites sp. (indet.)	0.5%

813 ft. 3 in.

Greenish grey carb. shale

Count 200 +

Alisporites spp.	84.0%
Apiculatisporis spp.	0.5%
Chordasporites sp. (indet.)	0.5%
Clavatisporites cf. *hammenii*	0.5%
Clavatisporites sp. (indet.)	0.5%
Converrucosisporites cameroni	0.5%
Cycadopites nitidus	2.5%
Densoisporites sp.	+
Dictyophyllidites mortoni	2.0%
Duplexisporites problematicus	0.5%
Equisetosporites steevesi	0.5%
Guttatisporites visscheri	+
Inaperturopollenites sp.	0.5%
Leiotriletes directus	3.5%
Osmundacidites spp.	1.0%
Polypodiisporites ipsviciensis	2.5%
Sulcosaccispora alaticonformis	+
Uvaesporites verrucosus	+
Vitreisporites sp.	0.5%
Striatites (indet.)	+

RACEVIEW FORMATION

697 ft. 11 in.

Dark grey shale

No count

Alisporites spp.
Densosporites raceviewensis
Dictyophyllidites mortoni
Duplexisporites problematicus
Inaperturopollenites sp.
Leiotriletes directus
Osmundacidites sp.
Polypodiisporites ipsviciensis

HELIDON SANDSTONE

675 ft. 9 in.

Grey siltstone

Count 200 +

Acanthotriletes sp.	0.5%
Alisporites spp.	44.0%
Anapiculatisporites dawsonensis	0.5%
Annulispora folliculosa	0.5%
Annulispora microannulata	+
Apiculatisporis sp. (indet.)	1.5%
Araucariacites sp.	0.5%
Cadargasporites reticulatus	0.5%
Ceratosporites helidonensis	+
Conaletes spp.	2.5%
Cycadopites granulatus	0.5%
Cycadopites nitidus	8.0%
Dictyophyllidites mortoni	2.5%
Discisporites psilatus	0.5%
Duplexisporites problematicus	+
Granulatisporites sp.	0.5%
Inaperturopollenites spp.	5.0%
Leiotriletes directus	10.0%
Lophotriletes sp. (indet.)	1.5%
Osmundacidites spp.	8.5%
Perinopollenites elatoides	4.5%
Polycingulatisporites crenulatus	0.5%
Polycingulatisporites mooniensis	+
Stereisporites antiquasporites	+
Stereisporites sp. (indet.)	4.0%
Verrucosisporites sp.	0.5%
Vitreisporites pallidus	2.0%
Acritarch (*Micrhystridium* sp.)	1.0%
Parasaccites sp. (reworked)	+

622 ft. 2 in.

Grey siltstone

Count 200 +

Alisporites lowoodensis	0.5%
Alisporites spp. (indet.)	56.5%
Anapiculatisporites dawsonensis	+
Araucariacites sp.	0.5%
Cadargasporites baculatus	+
Cadargasporites reticulatus	+

Ceratosporites helidonensis	+
Cingutriletes sp.	0.5%
Classopollis (incl. *C. meyeriana*)	5.0%
Clavatisporites sp.	0.5%
Conaletes sp.	2.0%
Converrucosisporites sp.	+
Cycadopites nitidus	2.0%
Densoisporites sp.	0.5%
Dictyophyllidites mortoni	1.5%
Discisporites psilatus	0.5%
Duplexisporites problematicus	+
Duplexisporites sp.	+
Foveosporites sp.	0.5%
Inaperturopollenites spp.	7.5%
Leiotriletes directus	5.0%
Osmundacidites spp.	2.0%
Perinopollenites elatoides	8.0%
Polycingulatisporites crenulatus	0.5%
Polycingulatisporites mooniensis	+
Stereisporites spp.	4.5%
Uvaesporites verrucosus	1.0%
Verrucosisporites sp.	0.5%

P.S. LOCKROSE 1

ESK BEDS

Core 11, 4004 ft.

Carb. shale

Count 200 +

Alisporites spp.	56.0%
Aratrisporites banksi	0.5%
Aratrisporites paenulatus	+
Aratrisporites strigosus	1.0%
Aratrisporites sp. (indet.)	1.5%
Araucariacites sp.	0.5%
Chordasporites sp. (indet.)	+
Converrucosisporites cameroni	1.0%
Cycadopites crassimarginis	1.0%
Cycadopites nitidus	10.0%
Dictyophyllidites mortoni	18.0%
Foveosporites mimosae	+
Inaperturopollenites spp.	2.0%
Indusiisporites sp.	0.5%
Leiotriletes directus	4.5%
Lophotriletes novicus	+
Lunatisporites pellucidus	+
cf. *Lycopodiumsporites* sp.	+
Neoraistrickia taylorii	+
Osmundacidites sp.	0.5%
Pilasporites cf. *crateraformis*	0.5%
Pilasporites sp. (indet.)	0.5%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	1.5%
Punctatosporites walkomi	0.5%
Sulcosaccispora alaticonformis	+

Core 10, 3886 ft. 5 in.

Carb. shale

Count 200 +

Alisporites spp.	58.0%
Apiculatisporis sp. (indet.)	1.0%
Aratrisporites strigosus	+
Clavatisporites cf. *hammenii*	0.5%
Conbaculatisporites spp.	1.0%
Converrucosisporites cameroni	1.5%
Cycadopites nitidus	0.5%
Dictyophyllidites mortoni	0.5%
Granulatisporites sp.	0.5%
Inaperturopollenites spp.	4.5%
Leiotriletes directus	3.5%
Lophotriletes sp. (indet.)	1.5%
Neoraistrickia taylorii	1.0%
Osmundacidites spp.	11.5%
Polypodiisporites ipsviciensis	13.0%
Tuberculatosporites aberdarensis	1.0%
Verrucosisporites sp.	0.5%

Core 9, 3623 ft.

Dark grey shale

No count

Alisporites spp.
Clavatisporites cf. *hammenii*
Cycadopites nitidus
Leiotriletes directus
Neoraistrickia cf. *taylorii*
Osmundacidites sp.
Polypodiisporites ipsviciensis
Stereisporites sp.
Sulcosaccispora alaticonformis

Core 7, 2962 ft. 9 in.

Dark grey carb. shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	81.5%
Chordasporites australiensis	0.5%
Clavatisporites cf. *hammenii*	0.5%
Cycadopites nitidus	7.5%
Dictyophyllidites mortoni	1.5%
Duplexisporites problematicus	+
Equisetosporites steevesi	0.5%
Guthoerlisporites cancellosus	+
Inaperturopollenites spp.	1.0%
Lunatisporites sp.	+
Osmundacidites spp.	4.5%
Polypodiisporites ipsviciensis	0.5%
Sulcatisporites sp.	+
Sulcosaccispora alaticonformis	+
Uvaesporites verrucosus	1.5%
Vitreisporites pallidus	0.5%

Core 6, 2651 ft. 11 in.

Grey carb. shale

Count 200 +

Alisporites spp.	54.5%
Apiculatisporis sp. (indet.)	2.5%
Aratrisporites strigosus	+
Clavatisporites cf. *hammenii*	2.0%
Conaletes sp.	0.5%
Converrucosisporites cameroni	0.5%
Cycadopites nitidus	7.0%
Densoisporites sp.	+
Dictyophyllidites mortoni	1.5%
Duplexisporites problematicus	+
Equisetosporites steevesi	0.5%
Guthoerlisporites cancellosus	0.5%
Guttatisporites visscheri	0.5%
Inaperturopollenites spp.	1.5%
Indospora clara	0.5%
Indusiisporites sp.	0.5%
Leiotriletes directus	3.5%
Lophotriletes sp. (indet.)	3.0%
Lunatisporites sp. (indet.)	0.5%
Osmundacidites spp.	9.0%
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	9.5%
Punctatisporites sp.	0.5%
Sulcosaccispora alaticonformis	+
Uvaesporites verrucosus	0.5%
Vitreisporites pallidus	0.5%

Core 5, 2205 ft.

Grey carb. shale

Count 200 +

Alisporites spp.	38.5%
Anapiculatisporites sp.	0.5%
Apiculatisporis clematisi	+
Apiculatisporis sp. (indet.)	2.5%

Aratrisporites cf. *paenulatus*	0.5%
Aratrisporites strigosus	+
Araucariacites sp.	0.5%
Baculatisporites cf. *comaumensis*	+
Clavatisporites sp. (indet.)	1.0%
Conaletes sp.	0.5%
Conbaculatisporites sp. (indet.)	1.0%
Converrucosisporites sp.	+
Cycadopites nitidus	5.5%
Dictyophyllidites mortoni	7.0%
Discisporites psilatus	0.5%
Duplexisporites problematicus	+
Guthoerlisporites cancellosus	0.5%
Inaperturopollenites spp.	11.0%
Leiotriletes directus	6.5%
Lophotriletes novicus	0.5%
Lophotriletes sp. (indet.)	0.5%
Osmundacidites spp.	5.0%
Pilasporites crateraformis	+
Polypodiisporites ipsviciensis	12.5%
Punctatisporites spp.	3.0%
Rugulatisporites sp.	0.5%
cf. *Rugulatisporites* sp.	0.5%
Verrucosisporites sp.	0.5%
Vitreisporites pallidus	+
Striatites (indet.)	0.5%

P.S. BAYLAM 1

ESK BEDS

Sidewall core 19, 2445 ft.

Shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	93.5%
Baculatisporites sp.	0.5%
Converrucosisporites sp. (indet.)	0.5%
Cycadopites nitidus	1.0%
Dictyophyllidites mortoni	+
Equisetosporites steevesi	0.5%
Foveosporites sp.	+
Leiotriletes directus	1.0%
Lophotriletes sp. (indet.)	0.5%
Osmundacidites sp.	0.5%
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	0.5%
Protohaploxypinus sp. (indet.)	0.5%
Vitreisporites pallidus	+
Striatites (indet.)	0.5%

Sidewall core 1, 2440 ft.

Shale

No count

Alisporites spp.
Converrucosisporites cameroni
Cycadopites nitidus
Inaperturopollenites sp.
Leiotriletes directus
Osmundacidites sp.
Platysaccus queenslandi

Sidewall core 20, 2438 ft.

Shale

No count

Accinctisporites ligatus
Alisporites spp.
Converrucosisporites cameroni
Dictyophyllidites mortoni
Guthoerlisporites cancellosus
Guttatisporites visscheri
Inaperturopollenites spp.
Osmundacidites spp.
Platysaccus queenslandi
Striatites (indet.)

Sidewall core 22, 2434 ft.

Shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	90.0%
Apiculatisporis sp. (indet.)	0.5%
Circulisporites parvus	0.5%
Converrucosisporites cameroni	0.5%
Cycadopites nitidus	2.5%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	2.0%
Guthoerlisporites cancellosus	+
Guttatisporites visscheri	0.5%
Guttatisporites sp.	+
Inaperturopollenites sp.	0.5%
Leiotriletes directus	0.5%
Neoraistrickia taylorii	+
Osmundacidites sp.	0.5%
Platysaccus queenslandi	+
Punctatosporites walkomi	0.5%
Verrucosisporites sp.	+
Vitreisporites pallidus	0.5%
Striatites (indet.)	0.5%

Sidewall core 24, 2203 ft.

Shale

Count 200 +

Alisporites spp.	56.0%
Apiculatisporis sp. (indet.)	4.0%
Aratrisporites wollariensis	2.5%
Converrucosisporites cameroni	1.0%
Cycadopites nitidus	5.0%
Dictyophyllidites mortoni	3.0%
Granulatisporites sp.	0.5%
Guttatisporites visscheri	2.0%
Inaperturopollenites spp.	7.0%
Indusiisporites sp.	+
Leiotriletes directus	7.0%
Lophotriletes sp.	0.5%
Neoraistrickia taylorii	1.0%
Osmundacidites spp.	3.5%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	0.5%
Punctatisporites spp.	4.0%
Rugulatisporites sp.	0.5%
Stereisporites sp.	0.5%
Verrucosisporites spp.	1.5%

Sidewall core 3, 2197 ft.

Shale

Count 200 +

Alisporites spp.	35.0%
Araucariacites sp.	2.0%
Clavatisporites cf. *hammenii*	1.0%
Converrucosisporites cameroni	4.5%
Cycadopites granulatus	0.5%
Cycadopites nitidus	2.5%
Dictyophyllidites harrisii	1.0%
Dictyophyllidites mortoni	15.0%
Guttatisporites visscheri	+
Inaperturopollenites spp.	11.5%
Indospora clara	+
Leiotriletes directus	16.0%
Leiotriletes sp. (indet.)	0.5%
Osmundacidites spp.	4.0%
Polypodiisporites ipsviciensis	0.5%
Punctatisporites fungosus	+
Punctatosporites walkomi	4.0%
Rugulatisporites sp. (indet.)	0.5%
Tuberculatosporites aberdarensis	1.5%

Sidewall core 4, 2186 ft.

Shale

No count

Alisporites spp.
Biretisporites sp. A
Clavatisporites cf. *hammenii*
Converrucosisporites cameroni
Cycadopites nitidus
Dictyophyllidites mortoni
Guthoerlisporites cancellosus
Guttatisporites visscheri
Leiotriletes directus
Lophotriletes novicus
Osmundacidites sp.
Platysaccus queenslandi
Punctatisporites sp.
Uvaesporites verrucosus
Verrucosisporites sp.

Sidewall core 26, 2182 ft.

Shale

No count

Alisporites spp.
Apiculatisporis sp. (indet.)
Cyathidites sp. (indet.)
Dictyophyllidites mortoni
Foveosporites mimosae
Foveosporites sp. (indet.)
Inaperturopollenites sp.
Leiotriletes directus
Punctatisporites sp.
Punctatosporites walkomi

Sidewall core 5, 2171 ft.

Sandstone

No count

Alisporites spp.
Apiculatisporis clematisi
Converrucosisporites cameroni
Cycadopites nitidus
Dictyophyllidites mortoni
Guttatisporites visscheri
Inaperturopollenites sp.
Leiotriletes directus
Osmundacidites sp.
Platysaccus queenslandi
Punctatisporites sp.

Sidewall core 28, 2157 ft.

Siltstone

Count 100 +

Alisporites spp.	45.0%
Apiculatisporis sp. (indet.)	3.0%
Aratrisporites paenulatus	+
Baculatisporites sp. (indet.)	1.0%
Converrucosisporites cameroni	2.0%
Cycadopites nitidus	15.0%
Dictyophyllidites mortoni	10.0%
Guttatisporites visscheri	+
Inaperturopollenites spp.	7.0%
Leiotriletes directus	11.0%
cf. *Matonisporites* sp.	1.0%
Neoraistrickia taylorii	1.0%
Osmundacidites spp.	2.0%
Platysaccus queenslandi	1.0%
Punctatisporites sp.	1.0%

Sidewall core 7, 2144 ft.

Sandstone

No count

Alisporites spp.
Apiculatisporis sp. (indet.)
Cycadopites nitidus
Cycadopites sp. (indet.)
Dictyophyllidites mortoni
Inaperturopollenites sp.
Leiotriletes directus
Osmundacidites sp.
Platysaccus queenslandi
Polypodiisporites ipsviciensis
Punctatisporites sp.
Stereisporites sp.
Verrucosisporites sp.
Striatites (indet.)

Core 4, 2093 ft. 6 in.

Carb. shale

Count 200 +

Alisporites spp.	75.5%
Apiculatisporis sp. (indet.)	2.0%
Aratrisporites banksi	+
Aratrisporites wollariensis	+
Aratrisporites sp. (indet.)	0.5%
Araucariacites sp.	0.5%
Converrucosisporites cameroni	+
Cycadopites nitidus	2.0%
Cycadopites sp. (indet.)	0.5%
Dictyophyllidites mortoni	0.5%
Guttatisporites visscheri	0.5%
Inaperturopollenites spp.	8.0%
Leiotriletes directus	4.0%
Lophotriletes novicus	+
Lophotriletes sp. (indet.)	1.5%
Osmundacidites spp.	3.5%
Platysaccus queenslandi	0.5%
Polypodiisporites ipsviciensis	0.5%
Protohaploxypinus sp.	+

Core 3, 1722 ft. 9 in.

Carb. shale

No count

Alisporites spp.
Aratrisporites sp. (indet.)
Cycadopites nitidus
Dictyophyllidites mortoni
Duplexisporites problematicus
Inaperturopollenites sp.
Leiotriletes directus
Lophotriletes novicus
Nevesisporites limatulus
Osmundacidites sp.
Stereisporites sp.

Sidewall core 9, 1362 ft.

Shale

Count 200 +

Alisporites spp.	47.5%
Apiculatisporis sp. (indet.)	2.5%
Brachysaccus eskensis	0.5%
Clavatisporites sp. (indet.)	1.5%
Cycadopites nitidus	9.5%
Cycadopites sp. (indet.)	1.0%
Densosporites raceviewensis	+
Densosporites sp. (indet.)	0.5%
Dictyophyllidites mortoni	3.0%
Discisporites psilatus	2.5%
Duplexisporites problematicus	0.5%
Equisetosporites steevesi	+

Equisetosporites sp. (indet.)	1.0%
Granulatisporites sp.	0.5%
Grebespora concentrica	+
Inaperturopollenites spp.	3.5%
Leiotriletes directus	2.0%
Lophotriletes spp.	2.0%
Lunatisporites sp.	0.5%
Neoraistrickia taylorii	+
Neoraistrickia cf. *taylorii*	0.5%
Neoraistrickia sp. (indet.)	0.5%
Osmundacidites spp.	12.5%
Polypodiisporites ipsviciensis	3.0%
Polypodiisporites sp. (indet.)	0.5%
Rugulatisporites sp. (indet.)	+
Stereisporites sp.	0.5%
Verrucosisporites spp.	2.5%
Vitreisporites pallidus	0.5%
Striatites (indet.)	0.5%
Acritarch (*Micrhystridium* sp.)	0.5%

Sidewall core 30, 1360 ft.

Shale

No count

Alisporites spp.
Aratrisporites strigosus
Araucariacites sp.
Cycadopites nitidus
Dictyophyllidites mortoni
Duplexisporites problematicus
Inaperturopollenites sp.
Kraeuselisporites verrucifer
Leiotriletes directus
Lophotriletes sp.
Osmundacidites sp.
Platysaccus queenslandi
Polypodiisporites ipsviciensis

Sidewall core 11, 1358 ft.

Shale

Count 200 +

Accinctisporites ligatus	+
Alisporites spp.	74.5%
Aratrisporites sp. (indet.)	+
Araucariacites spp.	1.0%
Converrucosisporites spp.	1.0%
Cycadopites crassimarginis	0.5%
Cycadopites nitidus	4.0%
Cycadopites sp. (indet.)	+
Dictyophyllidites mortoni	0.5%
Discisporites psilatus	2.5%
Duplexisporites problemsaticus	+
Equisetosporites steevesi	+
Foveosporites sp.	+
Granulatisporites spp.	1.0%
Inaperturopollenites spp.	4.0%
Indusiisporites sp.	1.0%
Kraeuselisporites sp. (indet.)	0.5%
Leiotriletes directus	1.0%
Leiotriletes sp. (indet.)	0.5%
Nevesisporites limatulus	+
Osmundacidites spp.	2.0%
Platysaccus queenslandi	+
Polypodiisporites ipsviciensis	3.5%
Punctatosporites walkomi	0.5%
Stereisporites sp.	0.5%
Sulcosaccispora alaticonformis	0.5%
Uvaesporites verrucosus	0.5%
Verrucosisporites sp.	0.5%
Striatites (indet.)	+

RACEVIEW FORMATION

Sidewall core 17, 1136 ft.

Sandstone

No count

Alisporites spp.
Annulispora microannulata
Baculatisporites cf. *comaumensis*
Densosporites raceviewensis
Inaperturopollenites sp.
Leiotriletes directus
Polycingulatisporites densatus
Polycingulatisporites mooniensis
Polypodiisporites ipsviciensis
Stereisporites sp.
Tuberculatosporites sp.

QUEENSLAND
DEPARTMENT OF MINES

GEOLOGICAL SURVEY OF QUEENSLAND
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ORIGIN OF SOME CAMBRIAN BEDDED CHERTS, AND OTHER ASPECTS OF SILICIFICATION IN THE GEORGINA BASIN, QUEENSLAND

by

P.J.G. FLEMING
Geological Survey of Queensland

BRISBANE
September, 1974

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ORIGIN OF SOME CAMBRIAN BEDDED CHERTS, AND OTHER ASPECTS OF SILICIFICATION IN THE GEORGINA BASIN, QUEENSLAND

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SUMMARY

Thin cherts interbedded with pelletal phosphorites of the *Xystridura* Zone (lower Middle Cambrian) in the Burke River Outlier are described. The occurrence of relict carbonate, of inclusions called "relict black rhombs", and similarity of chert fabrics to those demonstrably derived by silicification of recrystallized lime mud, show that the chert beds result from replacement of lime mud beds by silica. The replacement is early diagenetic and prior to compaction and final lithification in some examples. In other material, replacement may be late and even due to Tertiary weathering.

Several examples of calcareous nodules set in beds of heavily compacted pelletal phosphorite are described. The nodules consist of sand-sized carbonate and collophane grains, set in carbonate groundmasses. Some have recrystallized lime muds interbedded. The enclosing, more heavily compacted beds consist of collophane grains set in groundmasses of silica and carbonate. In examples where lime mud beds are cut off at the nodule boundaries, it can be shown that the nodular structures were formed by selective removal of carbonate followed by compaction. The compacted beds are petrographically similar to the high grade pelletal phosphorite beds of the Duchess deposits, and it is proposed that these high grade beds, though now usually silica cemented, were deposited in a carbonate environment.

INTRODUCTION

On the western margin of the Burke River Outlier of the Georgina Basin (Opik, 1961) in north-western Queensland, shales, phosphatic limestones, and phosphorites of the *Xystridura* Zone (lower Middle Cambrian) are interbedded with bedded cherts, composed mainly of microquartz (Folk, 1950). Maps of the phosphorite areas appeared in Thomson and Russell (1971) and Russell and Trueman (1971). The phosphatic rocks were grouped under the name Beetle Creek Formation by Russell (1967), de Keyser (1968), Thomson and Russell (1971), and Russell and Trueman (1971). The phosphatic limestones are composed of phosphatic and phosphatized sand-sized skeletal remains in carbonate matrix and cement, together with recrystallized lime mud beds. The high grade phosphorites are composed mainly of pelletal collophane particles in silica groundmass (pl. 1, figs 4-5) and have shale interbeds and much brown bedded chert (pl. 1, figs 1-2). The chert is black and apparently carbonaceous in the subsurface (Russell and Trueman, 1971, fig. 8). Upper nonphosphatic limestones (lower part of the Devoncourt Limestone; carbonate facies of the Inca Formation (Russell and Trueman, 1971)) are mainly recrystallized lime muds, poor in fauna. The western, possibly shoreward, facies (see Russell and Trueman, 1971) consists of cherts, quartz-rich fine sandstones and siltstones, and is extensively cemented by silica.

The present work is part of a project aimed at determining the origin of the phosphorite. In this connection, it has become important to determine the original depositional environments and ascertain the diagenetic history.

The first part of this paper presents results of petrologic investigations of the bedded brown cherts which occur in the phosphorite-phosphatic limestone suite of the Duchess deposits. The origin of these cherts has been the subject of discussion and some disagreement (de Keyser, 1969; Russell and Trueman, 1971).

Terminology used for cherts is that established by Tarr (1938), Folk (1950), Folk and Weaver (1952), and later reviewed by Pittman (1959).

The second part of the paper is concerned with the origin of calcareous nodules in high grade phosphate rocks from the Mount Murray area. These structures are not uncommon in beds of very high grade, silica cemented pelletal phosphorites of the Duchess deposits (Russell, 1967, p. 155) (pl. 1, figs 6-7). The high grade beds around the nodules are characteristically intensely compacted. The mode of origin postulated for the nodules yields a possible explanation for the occurrence of the enclosing beds of high grade phosphorites.

Material and localities

Specimens used are mainly the writer's collections from outcrop and sub-outcrop in the Duchess embayment whose geographic features are shown by Russell and Trueman (1971, fig. 4), supplemented by diamond drill cores sampled by permission of Broken Hill South Ltd. The material figured or referred to by specimen numbers or diamond drill hole depths is in the collection of the Geological Survey. The diamond drillholes mentioned in the paper are DDHD9 located about 2500 m north of Mount Murray, and DDHD11 about 600 m northeast of Roger's Ridge. Locality 38 is a large outcrop of siliceous phosphorite in Monastery Creek south of Rimmer Hill. Locality 40 is a costean cut on the north slope of Mount

Murray. Specimen 40.24 is from the costean. Specimens P61-1 to P61-8 are from outcrops of predominantly calcareous phosphate rock about 0.8 km north of Mount Murray.

Acknowledgements

My thanks are due to J.T. Woods who suggested my work on phosphate genesis and who has given me continued support; to R.T. Russell, previously of Mines Exploration Pty Ltd, for supplying information and discussing ideas developed during exploration of the phosphate deposits; to P.J. Davies for much assistance and criticism; and to G.R. Orme and F. de Keyser for valuable discussion.

BROWN CHERTS OF THE DUCHESS PHOSPHATE DEPOSITS

PROPERTIES OF THE CHERTS

Macroscopic features

Rocks grouped under the heading "brown cherts" comprise thin, poorly fossiliferous, weakly phosphatic, darker beds of the large outcrop in Monastery Creek (pl. 1, figs 1-3); thin, dark, splintery beds a few millimetres to a few centimetres thick in the trench at Mount Murray; and similar beds in diamond drill cores and at the surface over the phosphate deposits. "Brown cherts" form a convenient group, distinguished from other types of chert and siliceous beds and nodules by thin bedding, brownish colour, paucity of fossils, and fineness of grain size. The brown colour in surface material is probably due to fine iron oxide after pyrite, to other small inclusions, and to the optical effect of chalcedonic quartz (Folk and Weaver, 1952).

In outcrops in the siliceous facies (see Russell and Trueman (1971)), the chert beds are very persistent, continuous for many metres, even when only laminae. Their upper and lower contacts with pelletal, silica cemented beds are quite sharp (pl. 1, figs 1-3). Many of the chert beds contain layers of collophane pellets only one pellet thick; some of these expanding to thicker beds. Botryoidal surfaces do not occur on the surfaces of the beds. Some beds have open vertical cracks, the expanded cracks often containing pellets of the adjoining beds. Flat bedding without internal laminae is characteristic. Flame structures (pl. 1, fig 3) and cross bedding rarely occur in or near the chert beds.

Lateral contacts of brown chert and limestone are rarely seen, although much of the brown chert is interlayered with limestone and partly replaces carbonate in drill cores.

Microscopic features

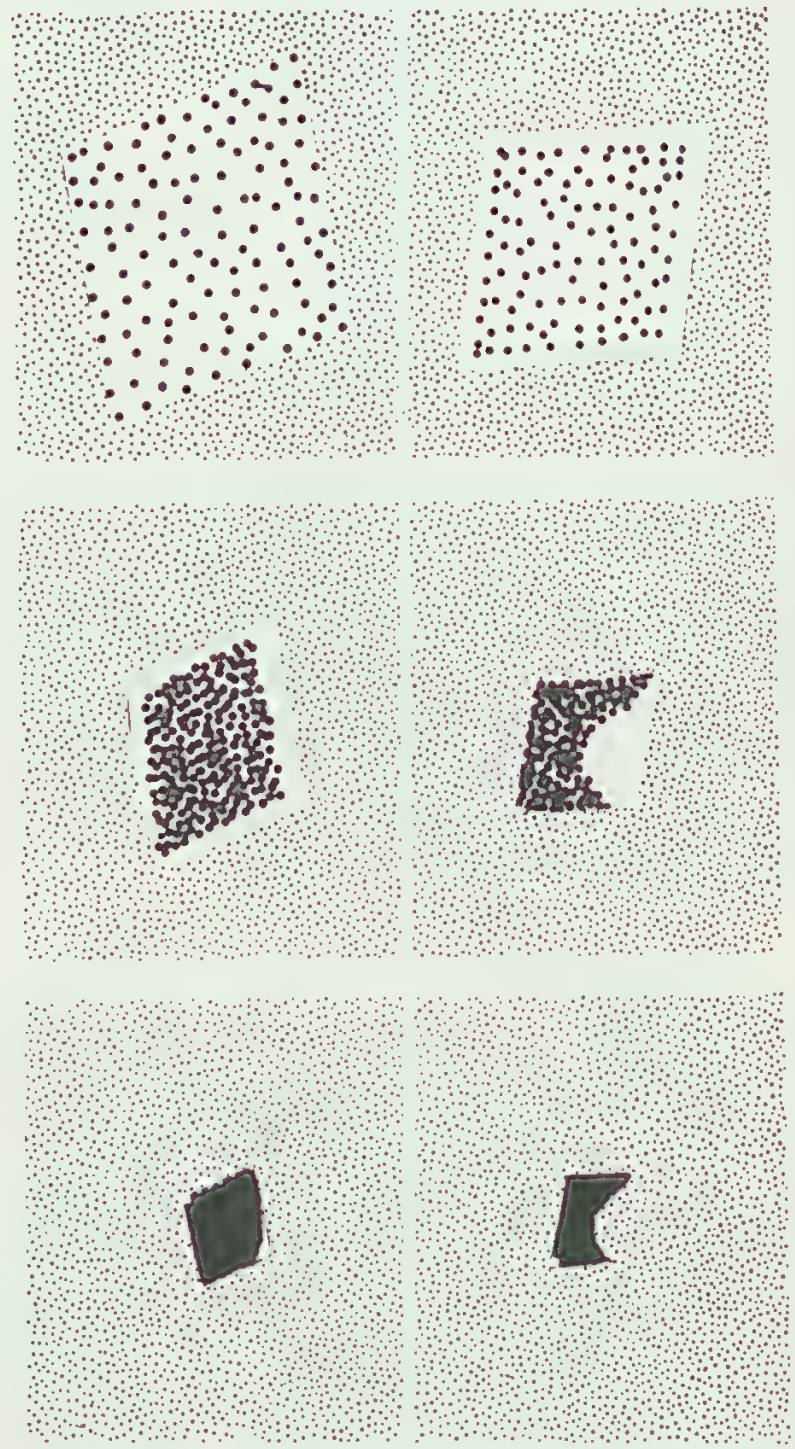
The brown cherts consist principally of microquartz. Some crystals and patches of quartz grains are of larger size and usually have wavy extinction. This fabric is likely to be the result of recrystallization of replacive chalcedony (Bathurst, 1964, p. 328). The grain size of silica in brown chert tends to be larger near pellets, even where they are included as layers only one pellet thick. The typical fabric of the chert is shown in pl. 2, figs 1-2. Most material appears to have suffered some recrystallization.

Surface samples of chert consist of fine-grained silica with subordinate iron oxide grains, fine detrital mica flakes, and rare small collophane particles. Relict carbonate is rare, though 'relict black rhombs', described below, are abundant.

Relict black rhombs

Two types of particles are dispersed through the silica of brown cherts and some pelletal phosphorites (pl. 1, figs 4-5) with microquartz and fine mosaic quartz groundmasses. They give the rocks their dirty appearance in thin section. Both types are shown together in pl 2, fig 11. The first type consists of crystals and clumps of crystals of iron oxide, which may be the weathering product of pyrite. The other type displays rhombic to irregular shapes, composed wholly or partly of extremely fine discrete inclusions (pl. 2, figs 8-11). The incompletely filled particles usually have a groundmass of silica, but some have carbonate centres, and many have carbonate rims (pl. 2, figs 8-11). Carbonate rhombs with central

TEXT FIGURE 1



Diagrammatic representation of formation of relict black rhombs, showing progressive expansion of the silica (stippled), replacement of carbonate, and concentration of inclusions. Three stages are shown in the replacement of two calcite rhombs.

rhombic patches of minute inclusions are common, particularly in subsurface samples. These structures could have formed by inward migration of dispersed inclusions within carbonate rhombs, as the rhombs were reduced in size during silica replacement. Stages in the postulated formation of two relict black rhombs, one regular, the other irregular, are shown diagrammatically in text-fig. 1. According to this postulate, the size of the relict black rhomb bears no relation to the original size of the carbonate rhomb, but depends on the amount of matter originally dispersed in it. Thus, a small percentage of these relict black rhombs in a thin section does not mean that only a small proportion of the original sediment was carbonate. On the other hand, a large number of relict black rhombs in a chert suggests that silica has replaced carbonate. There is no reason to suppose that carbonate rhombs have grown around black rhombs in a primary siliceous sediment, for such growth would not explain the origin of carbonate rhombs which have two or more concentric zones of inclusions. It is significant that relict black rhombs or their postulated stages of formation are not seen in any unreplaced carbonates; that carbonate rhombs with dark centres are common in rocks from the subsurface with about equal quantities of carbonate and silica; and that relict black rhombs are most common in microquartz cherts.

The relict black rhombs are dark in transmitted light, but in polished sections are light coloured. This is probably due to scattering of transmitted light by the inclusions constituting the rhombs. In this respect, they resemble the corroded pseudo-opaque dolomite rhombs described by Pittman (1959, pl. 5, fig. 2), but they are not otherwise similar. Attempts to study relict black rhombs by electron microscopy were unsuccessful.

In the only lateral contact seen between brown chert and pseudospar after micrite (pl. 2, figs 3-11), the distribution of rhombs is as follows. None occurs in the pseudospar, a few carbonate rhombs with dark centres occur near the contact, and relict black rhombs are common in that part of the bed which is now completely silicified. The numbers of relict black rhombs in the siliceous part of the replaced bed are compared with the numbers in other chert samples in Table 1.

It is apparent in this specimen that the silica is replacing carbonate (pl. 2, fig. 4). The distribution of the relict fabric is consistent with the postulated mode of formation of relict black rhombs. Insoluble residue of the pseudospar contains extremely fine dark inclusions, which are the probable source of the material making up the relict black rhombs.

Relict black rhombs resemble the dolomite rhomb shown by Murray (1964, fig. 7) in early stages of replacement by silica. However, the parent material in the present study is not necessarily dolomite. In many examples of Duchess material the rhombs are known to be calcite.

Weathering

The long-exposed rocks of the Georgina Basin have been subjected to deep weathering (see Russell (1967)), and to silicification such as that recorded by Paten (1964). In considering the role of surface silicification in the formation of brown cherts, the following evidence is pertinent.

(a) Brown chert beds in cores usually have relict car-

TABLE 1

P61-4		40.10		38.6/4		40.1		38.4/7		38.4/7		50.1		D9,54-51	
1	14	1	16	1	7	1	6	1	18	1	9	1	9	1	18
2	18	2	19	2	13	2	15	2	20	2	14	2	17	2	16
3	20	3	13	3	17	3	13	3	15	3	7	3	19	3	15
4	13	4	12	4	9	4	9	4	12	4	9	4	22	4	19
5	8	5	11	5	11	5	11	5	7	5	10	5	11	5	13
6	10	6	13	6	12	6	8	6	14	6	18	6	13	6	12
7	11	7	15	7	16	7	5	7	12	7	14	7	12	7	5
8	16	8	10	8	8	8	8	8	13	8	6	8	11	8	19
9	7	9	7	9	15	9	11	9	19	9	17	9	16	9	20
10	14	10	10	10	10	10	7	10	11	10	15	10	20	10	14

Table 1. Numbers of relict black rhombs in each of 10 fields of view for some sample thin sections of brown cherts. Field of view selected at random and delimited by an ocular grid and the 25x objective. Counts include all rhombs recognisable through the whole thickness of the thin sections.

bonate; similar beds in outcrop seldom have relict carbonate. This suggests that the carbonate may have been silicified at or near the present land surface or an older land surface. On the other hand, due to poor exposure, the brown chert of outcrop may be entirely from the intensely siliceous facies, and none may have been collected from the zone of interfingering of siliceous and carbonate facies. Moreover, the occurrence in core DDHD11 of brown chert with relict carbonate at a depth of only 3 m casts doubt on the possibility of near-surface silicification of relict carbonate.

(b) In samples from locality 40, locality 38, and from DDHD11 at 7.5 m, brown chert is cracked by compaction, and allochems from adjoining beds fill the cracks, indicating that silicification predates compaction. This evidence establishes that the phenomenon of brown chert formation is not always associated with late stage near-surface silicification, since the compaction is contemporaneous with early diagenesis.

(c) There is no regular change in silica content with depth in any given drill core, and therefore, no evidence that directly links brown chert formation with surface weathering and associated silicification.

(d) In near-surface samples, collophane particles are generally darker in siliceous beds than in carbonate beds (pl. 3, fig. 5; pl. 4, fig. 1). If the overall dark colour of the collophane is due to included organic matter, lighter colours would be expected under conditions of near-surface oxidation. Russell and Trueman's (1971, p. 1210) report of higher organic content in collophane from below the oxidized weathered zone supports this hypothesis. The observed connection between colour variation of collophane particles and lithology suggests that the siliceous beds have shielded the collophane from oxidation more effectively than the carbonate beds. This, in turn, indicates that the silicification predated deep weathering.

ORIGIN OF BROWN CHERT

Replacement of carbonate

The following discussion of evidence indicates origin of the brown cherts by replacement of carbonate.

(a) The fabric of the chert of sample P 61-4, which formed by replacement of re-crystallized lime mud by silica, is indistinguishable from that of other brown cherts, and it is considered probable that all the known brown cherts originated by similar replacement. The nature of the process is quite independent of the origin of the replacive silica, and the time of its introduction.

(b) There is an abundance of relict black rhombs in both surface and subsurface samples of brown chert. The occurrence of relict black rhombs indicates that the cherts formed by silicification of carbonate.

(c) Relict carbonate occurs in almost all brown chert from cores, and in some outcrop samples, notably those from Monastery Creek. However, this is sometimes difficult to distinguish from the small amount of late diagenetic carbonate which post-dates the introduction of the silica of the brown cherts.

(d) A gradation in fabric between brown chert and partly replaced limestone beds is found in cores. DDHD11 cored interfingering siliceous and carbonate facies between the surface and about 40 m. The brown chert beds of this core contain considerable relict carbonate in patches, and relict carbonate rhombs with and without concentrated inclusions. It is possible that this whole zone is the large scale equivalent of the condition shown in specimen P 61-4.

(e) Some brown chert beds show cracks containing pellets from adjoining pelletal beds. This suggests that the chert was hard and brittle before the pelletal beds were cemented by silica.

(f) Relict rhombic grain boundaries occasionally occur in the microquartz of brown cherts.

This evidence strongly favours formation of the brown cherts by volume-for-volume replacement. Points (a), (b), (d), and (e) are not considered capable of explanation other than by an hypothesis involving replacement; point (c) is not at variance with this, while point (f) suggests that brown cherts could have been formed early in diagenesis.

Evidence consistent with a primary origin for the brown cherts is as follows:—

(a) They are flat-bedded and continuous.

(b) Readily identifiable inclusions of relict carbonate are not seen in surface material.

(c) Some primary structures, such as thin flat bedding, flame structures, and cross-bedding, which could have been destroyed by severe diagenetic alteration, are preserved.

(d) There are often cracks in the cherts, which are sometimes infilled by pellets from adjoining beds of pelletal phosphorites cemented by silica. This suggests that cracking, and therefore the presence of solid chert, predated cementation by silica of the adjoining pelletal beds.

This evidence for a primary origin is not conclusive, and all points are capable of accommodation in a replacement hypothesis. Russell and Trueman (1971, pl 1209) stated that few cherts show any textural evidence of metasomatism, and concluded (p. 1211) that the cherts are primary, or were replaced before consolidation. However, the writer concludes that replacement probably occurred after recrystallization of micrite to pseudospar, and he has not recognized any primary deposition of silica in the brown cherts of the Duchess phosphate deposits.

Nature of original carbonate sediment

Evidence bearing on the type of carbonate sediment which is believed to have yielded the brown chert by silicification, is as follows:—

(a) The arrangement of numerous fine inclusions of iron oxide suggests their derivation from disseminated pyrite formed in carbonate mud prior to lithification.

(b) No allochemical bed seen in the cherts or carbonates contains as many iron oxide inclusions as the lime mud beds or the brown cherts. This supports the evidence above.

(c) Very few allochems (sand sized grains) occur in brown cherts, and ghosts of allochems are very rare. This suggests that the replaced beds were originally micritic.

(d) Preserved structures in brown cherts, such as the

flame structures of pl. 1, fig. 3, could have formed in carbonate muds.

(e) In material from the Templeton River Outlier, a silica fabric similar to that of the brown cherts is found in partial geopetal fillings of hyolithid shells, which would be expected to have contained originally micritic material.

In P61-4 (pl. 2) the lime mud beds were recrystallized to pseudospar before replacement by silica with relict black rhombs. It is suggested that all brown cherts of the Duchess phosphate deposits, and which have similar relict black rhombs, formed from recrystallized lime muds. If the original carbonates had been micrites which had not recrystallized to pseudospar (aggradative neomorphism of Folk (1965)), they would not have produced relict black rhombs in the manner shown in text-fig. 2.

Many cherts in the Lady Annie phosphate deposits have a different composition. They represent silicified carbonate sands, with ghosts of sand-sized allochems visible because of differences between their fabric and that of the groundmass. Similar silicified carbonate sands were figured by de Keyser (1969, figs 32-35).

CALCAREOUS NODULES FROM THE MOUNT MURRAY AREA

DESCRIPTION

Nodular calcareous bodies commonly occur in beds of high grade, heavily compacted pelletal phosphorite near Mount Murray, and similar structures occur in several drill cores. Most examples are from the zone of interfingering of calcareous and siliceous facies in a trench and in surface rubble north and west of Mount Murray. The calcareous nodules consist of carbonate cemented sands, the allochems of which are mostly phosphatic and consist of faecal and micrite pellets and skeletal fragments. The enclosing beds, which are heavily compacted around the nodules, are composed of the same kinds of allochems, but usually have silica, or a mixture of silica and carbonate cements. Similar structures were described by de Keyser (1969, p. 17), who concluded that replacement of siliceous sediments by carbonate did not produce these structures, and that the concretions were not transported as boulders. Several examples, representative of as wide a range as possible, are described below.

Specimen P61-3 (pl. 3, figs 1-6; pl.4, figs 1-6; text-fig. 2). In this example the bedding of lime muds in the calcareous nodule extends into the silica cemented pelletal phosphorite, but is slightly displaced, due to compaction, and much thinner (pl. 3, figs 1, 2; text-fig. 2). This reduction in thickness is due to removal of carbonate, which has left only a few allochems and a concentration of impurities (pl. 3, fig. 4). Dark patches along the bedding traces result from the alteration of collophane pellets to birefringent phosphate. The differences between fabrics of the calcareous and siliceous pelletal beds are shown in pl. 3, figs 5-6 and pl. 4, figs 1-2. The more compacted silicified beds (pl. 3, fig. 1) have more numerous grain contacts. The zone of transition between the siliceous and the calcareous pelletal beds is about 1 mm wide (pl. 3, fig. 3). Within this zone, silica replaces calcite by embayment. Where embayments are very small, the calcite appears to be replaced by silica along cleavages. The silica contains relict calcite. In the siliceous part of the specimen, the coarser quartz mosaic is clear and the microquartz contains abundant inclusions of iron oxide and a few relict black rhombs. The clearer, coarser quartz may result from replacement of the original calcareous cement, and the microquartz from replacement of lime mud.

TEXT FIGURE 2

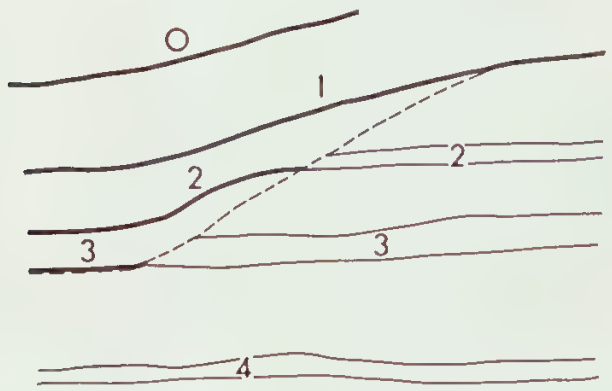


Diagram of specimen P61-3 (pl. 3, fig. 1), showing the contact between the nodule and the siliceous phosphorite as a dotted line. O, 1, 2, and 3 are remnants of lime mud beds. 2, 3, and 4 are recrystallized lime mud beds. 2 and 3 are continuous across the contact.

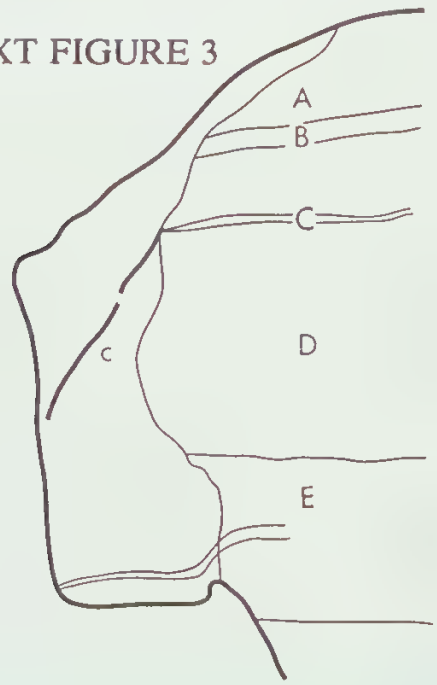
Specimen P61-2 (pl. 5, figs 1-3). This specimen contains part of a calcareous nodule over 15 cm in diameter. The nodule is composed of phosphatic allochems in a carbonate groundmass, with some interbeds of recrystallized lime mud. Bedding is disrupted in part of the specimen (pl. 5, fig. 1). The material surrounding the nodule consists of heavily compacted phosphatic allochems cemented by silica, with fabrics very similar to that of the previous specimen. In both the silica cemented beds and the disrupted part of the specimen, phosphate particles have been altered in patches to the same birefringent mineral shown in pl. 3, figs 1-2. There are no recognizable relicts of lime mud beds in the siliceous part of the sample, but they are abundant in the carbonate part. This suggests that the bedding was destroyed during compaction of the sediments surrounding the nodule, or by removal of carbonate prior to emplacement of the silica. Relict carbonate occurs in the siliceous cement, and silica replaced carbonate at the main silica-carbonate boundary. Disruption of bedding in part of the nodule is thought to be due to shearing during compaction. Beds of recrystallized mud have been broken up and have, in part, become veins of carbonate (pl. 5, fig. 2). The zone between the silica cemented and carbonate cemented areas is similar to that in the previous specimen. However, there are, in addition, numerous very fine cracks, vertically aligned and filled with calcite, which cut across both allochems and the silica groundmass. From this condition, it appears that the cracks opened and were filled by carbonate after silica emplacement, which implies that final compaction did not predate final silicification.

This example demonstrates that the relationship between silica and carbonate in groundmasses is not necessarily one of simple replacement. Silica may be emplaced both before and after compaction, and carbonate may be redistributed during or after silica emplacement.

Specimen P50-5 (pl. 4, fig. 7; text-fig. 3). This specimen shows an abrupt contact between a calcareous nodule and pelletal beds cemented by silica. Text-fig. 3 shows bed B of recrystallized lime mud terminating at the contact, leaving no trace in the siliceous beds. Bed C is

sharply cut off, but is traceable as a steeply angled line, which shows the degree of compaction suffered by the material. Bed E is reduced in thickness by about two-thirds at the contact, and is continued as a white, fine grained bed, consisting of a mixture of silica and carbonate grains. Inclusions are more densely distributed in the siliceous portion of bed E than in the calcareous part. The sharp cut-off of B, C, and E shows that this is not merely due to non-cementation by calcite in part of the specimen, and, together with the compaction features observed, indicates removal of carbonate, There is very little silica in beds D and E in the nodule, so the silica cement of the siliceous part was introduced during or subsequent to carbonate removal. The reduction in thickness of bed E by two-thirds suggests that there was incomplete removal

TEXT FIGURE 3



Drawing from specimen P50-5 (pl. 4, fig. 7), showing beds labelled A to E as in the photograph, and the compacted continuation of beds C and E to the left of the nodule.

of carbonate. However, neither the time of emplacement of silica, nor the manner of its emplacement (by pore-fill or replacement or both), is known.

Specimen 40.24 (pl. 5, fig. 4). This example has, in the calcareous nodule, a complex set of calcite, silica, and pyrite veins, which incorporate some of the collophane allochems of the host rock. In the top and bottom barts of the specimen, collophane allochems are set in a groundmass of microquartz intermixed with fine grained carbonate. Some of this microquartz replaces carbonate, so the carbonate may represent remnants of an originally calcareous cement. Darker bands in the siliceous part of the specimen are interpreted as former laminae of recrystallized lime mud, now silicified. One of these bands is considered to pass from the silicified beds into the calcareous nodule. The bands are compacted and draped over the nodule, but the carbonate veins are confined to the nodule (pl. 5, fig. 4). Differential compaction and cut off grains show that carbonate has been removed from the groundmass outside the nodule. It is suggested that the calcite veins formed prior to removal of carbonate from the groundmass. Following carbonate removal, the material around the nodule was compacted, and silica introduced during or after this compaction.

Specimen P61-1 (pl. 5, figs 5-6; text-fig. 4). The material shown to the left of the silica-carbonate contact (pl. 5, fig. 5; text-fig. 4) consists of tightly compacted collophane grains cemented by silica. To the right of the contact, the collophane grains are less compacted, and are set in a calcitic groundmass. Only two laminae (text-fig. 4) are considered to be traceable across the contact between the silica cemented and carbonate cemented areas. Shelly fossils appear to be more abundant in the carbonate cemented part of the specimen (pl. 5, fig. 6); however, close observation shows that the shells are present in similar numbers in the silica cemented part, but are compressed between the other particles, and are therefore less noticeable. The silica cemented beds are draped in a manner consistent with the degree of compaction shown by the particles.

TEXT FIGURE 4

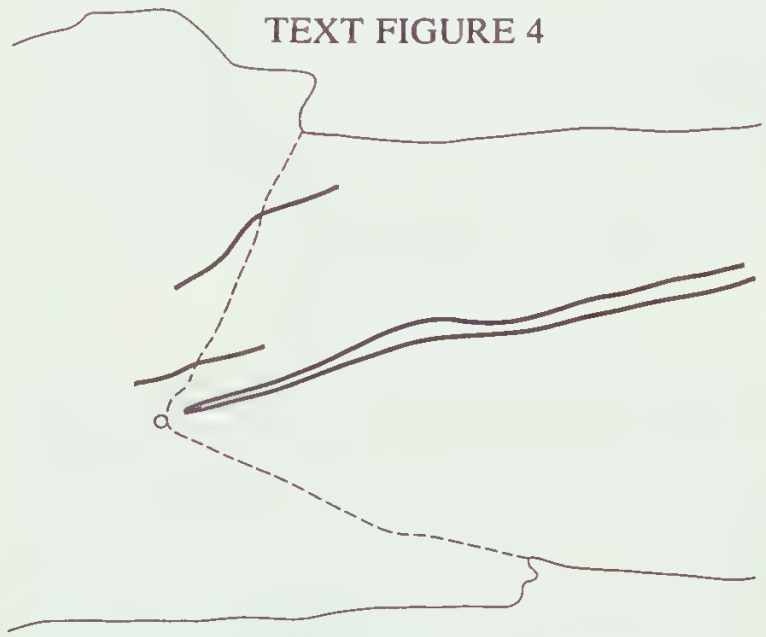


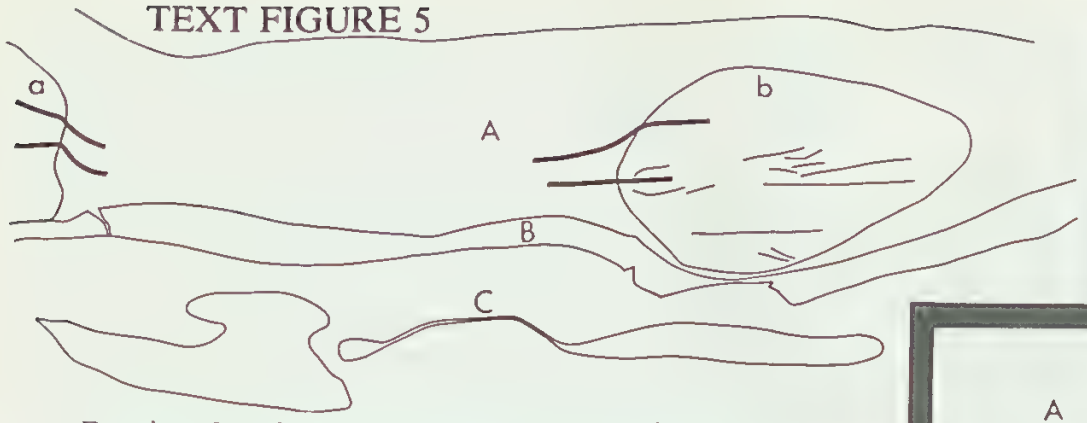
Diagram of specimen P61-1 (pl. 5, fig. 5), showing the lime-silica contact as a dotted line, and lime mud beds and their continuations across the contact.

The probable continuation of two beds across the lime-silica boundary suggests origin by either (a) cementation by carbonate of a nodule, followed by compaction and cementation by silica of the surrounding beds, or (b) cementation of the whole by carbonate, followed by removal of carbonate from the now siliceous part, compaction, and cementation by silica. Unlike some other specimens described, in which lime mud beds are abruptly cut off against the contact, either process of formation could have been operative here.

Specimens P61-7 and P61-8 (pl. 6, figs 1-7; text-figs 5-6). The carbonate nodules are set in beds with grains much broken by compaction (bed A, pl. 6, figs 1 and 3). The carbonate intergranular matrix of the enclosing beds also shows evidence of having suffered compaction, indicating that it does not post-date the compaction. Unlike specimens discussed so far, these contain beds which suffered very early silicification (pl. 6, fig. 1, B; fig. 3, B; text-figs 5-6, B), and the bed (pl. 6, figs 1 and 3, bed A) enclosing the nodules is non-siliceous.

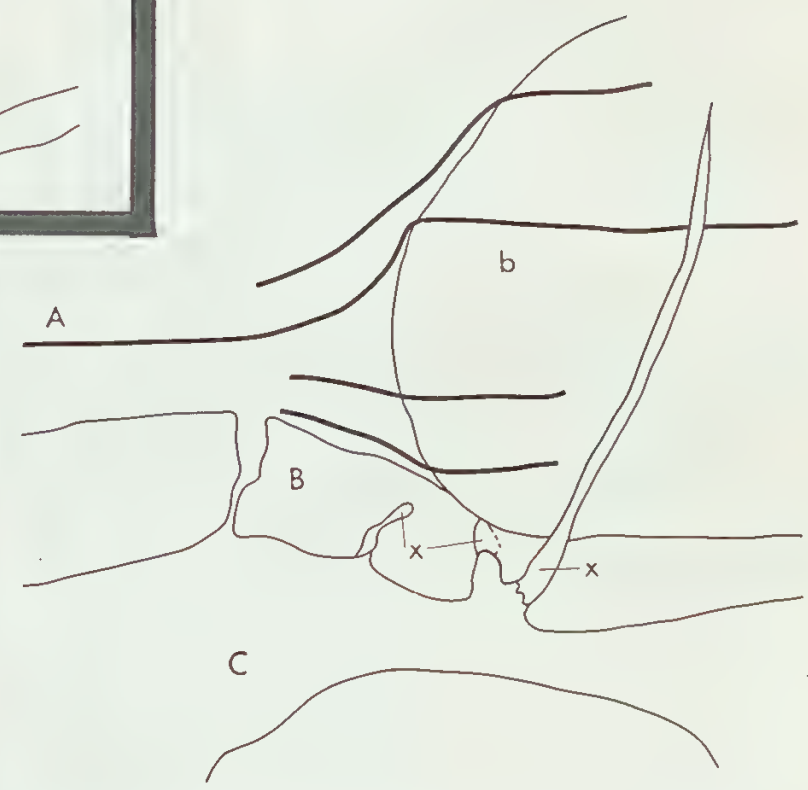
The nodules consist of micrite and phosphate pellet limestone (pl. 6, figs 5-6), mainly level bedded, but cross-bedded in places. Grain-support is indicated by the disposition of collophane and recrystallized micrite pellets. Furthermore, the interstitial calcite is clear, suggesting

TEXT FIGURE 5



Drawing of specimen P61-7 (pl. 6, fig. 3), showing nodules a and b, with small cross beds, compacted beds A and C, and beds extending across the nodule boundaries into the compacted beds.

TEXT FIGURE 6



Drawing from specimen P61-7 (pl. 6, fig. 2), showing chert bed B broken by compaction beneath nodule b, calcite-filled cracks x, and beds extending from b into compacted bed A.

that it represents cement rather than recrystallized lime mud. Where displacement by compaction has not been too great, bedding within the nodules can be traced into the surrounding compacted beds (pl. 6, fig. 2; text-fig. 6). The nodules therefore are not introduced limestone pebbles. However, it is not possible to decide whether they are concretionary structures cemented more fully than the surrounding compacted beds, or whether these beds suffered carbonate removal prior to compaction.

The sequence of events in the formation of bed A is considered to have been:—

(a) deposition of carbonate and phosphate allochems;

(b) lithification by carbonate cementation and hardening of interstitial lime mud;

(c) silicification in patches and nodules coincidental with or prior to

(d) removal of some carbonate, apparently by solution;

(e) compaction, crushing decalcified sediments and breaking silica, some of the crushed material passing into the cracks in the silica;

(f) introduction of lime into void space in unfilled cracks in the silica bed. Evidence of late interstitial lime cementation has not been recognized.

The alternative sequence seems to involve complete cementation in step (b), but only in the nodules, which removes the necessity for step (d), and allows substituting "decalcified" in step (e) by "incompletely cemented". This particular example offers no choice between the alternatives.

ORIGIN OF CALCAREOUS NODULES

Since evidence of subaerial emergence of the lime-phosphates during diagenesis has not been seen, and since carbonate cementation generally appears to have occurred before compaction, it is considered that calcareous cementation took place in the submarine environment soon after deposition. Submarine cementation by carbonate has been demonstrated by Gevirtz and Friedman (1966), Bartlett and Greggs (1970), Taft (1968), Allen *et al.* (1969), Zankl (1969), and Land and Goreau (1970). Because the cements are extremely recrystallized, no decision as to whether cementation was initially by aragonite or calcite is possible.

Samples P 61-2, P 61-3, P 50-5, and 40.24 show that there was removal of carbonate from the sediments prior to compaction and prior to, or coincident with, recementation of the compacted sediment by silica. In sample 40.24, the carbonate veining may be the result of redeposition of carbonate from elsewhere. In sample P 61-3, the compacted part is completely cemented by silica, but in P50-5 and 40.24 the compacted parts contain mixtures of silica and carbonate cements. The carbonate is thought to be mainly relict, though conclusive proof is lacking.

Carbonate may have been removed from sample P61-1, but as there are no beds of lime mud nor veins of carbonate cut off by solution, this cannot be proved. The specimen is similar in this respect to lime-phosphate nodules left by weathering in the Monastery Creek outcrop at locality 38.

A specimen used by de Keyser (1969, appendix, fig. (24), in his discussion regarding silicification of carbonate, shows beds crossing the carbonate-silica boundary. Specimen P61-7 is somewhat similar. These nodules are either remnants after carbonate removal or concretionary structures developed before cementation of the remainder. Clearly they are not boulders in the sediment.

De Keyser (1969, appendix) concluded that the carbonate nodules were remnants of cemented lime-phosphates, which had suffered volume reduction during silicification. Samples P61-7 and P61-3 show that compaction rather than silicification is the main cause of volume reduction. De Keyser's argument that the siliceous phosphorites in general were derived from original carbonate sediments depends heavily on his interpretation of the carbonate nodules in the trench at Mount Murray. However, though this work supports de Keyser, silicification of other material can be proved independently of these structures. For instance, brown cherts and cherty cements of some pelletal phosphorites in

the Duchess deposits (pl. 1, figs 4 and 5) can be shown by evidence independent of the carbonate nodules to be silicification products.

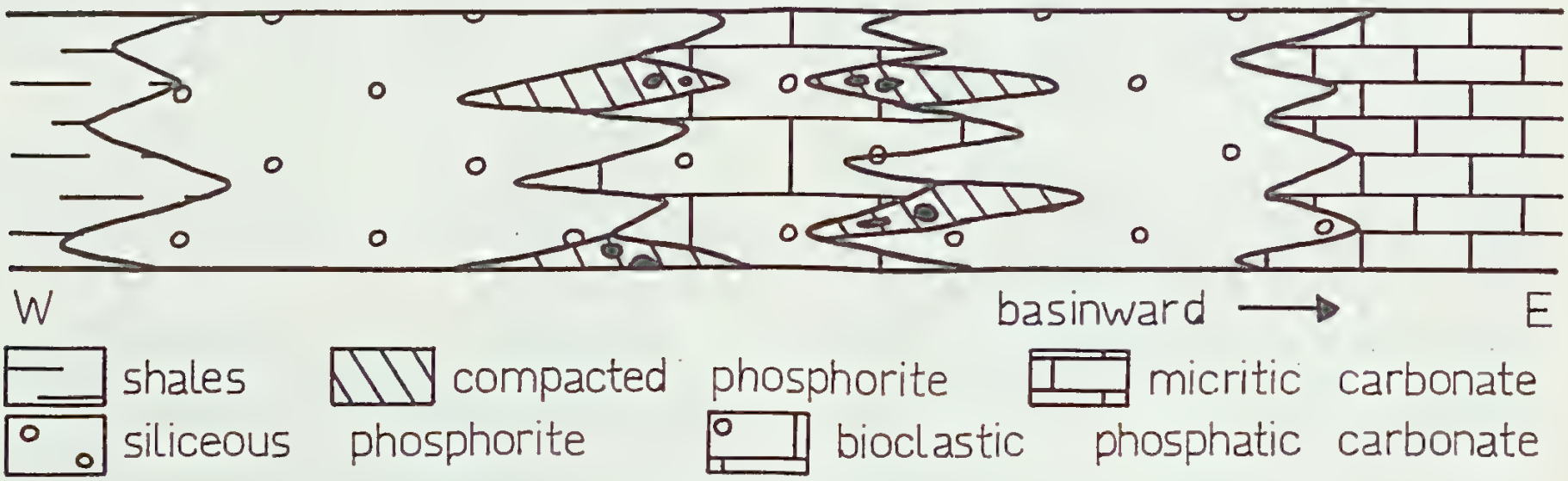
Russell and Trueman (1971, p. 1207, p. 1211) concluded that the cherts of the Duchess deposits are primary in origin. They mention views of de Keyser (1969) and Cook (*in* de Keyser and Cook (1972)) on the origin of "boulders" from the exploratory trench at Mount Murray, but regard the "occurrence and petrography of the boulders and enclosing cherts" as indicating mechanical break-up of carbonate beds. There is no reason to suggest that primary structures in carbonate should not be preserved after replacement of the carbonate by silica. Therefore, Russell and Trueman's assertion that primary sedimentary structures in cherts in nearby exposures are inconsistent with widespread silicification cannot be supported. Extremely high grade phosphorites were considered by Russell and Trueman (1971, p. 1207) to be primarily poor in matrix, due possibly to winnowing away of silica by current action. De Keyser and Cook (1972) present the opposing views of the joint authors on the origin of carbonate nodules in higher grade phosphorite beds at Mount Murray. Cook (in de Keyser and Cook, *op. cit.*) regards the process of formation of the nodules as the calcification of siliceous beds. This view was discussed by de Keyser (1969, appendix, p. 17).

CONCLUSION

Very high grade beds of overpacked pelletal phosphorite are common in the Mount Murray region where the coarser sandy lime-phosphates occur most abundantly, but very high grade beds are relatively rare in siliceous phosphorites in drill cores and at Monastery Creek. Possibly, when more exposures are made available by mining it will be found that the overpacked beds thicken towards and grade into the lime phosphates, and that they thin towards the interbedded brown cherts and cherty pelletal phosphorites (pl. 1, figs 4-5), which are both considered to have been formed by volume-for-volume replacement of carbonate by silica. The postulated distribution within the Beetle Creek Formation is shown in text fig. 7.

These very high grade pelletal phosphorites, which occur in beds up to about 0.3 m thick, and which are characterized by overpacking of allochems and fine grained quartz mosaic cement (pl. 1, figs 6-7), are very similar in fabric to the siliceous parts of the examples described in this paper. It is suggested that these beds (referred to by Russell (1967); Russell and Trueman (1971, p. 1207)) were formed originally in a carbonate environment. Some of them were cemented by carbonate, which was then removed and replaced by silica. Others may not have been cemented by carbonate, except in patches, but were compacted and cemented by silica. None of the material seen indicates that the silica cement of the overpacked pelletal beds is primary.

TEXT FIGURE 7



Postulated distribution of compacted phosphorite in the Beetle Creek Formation in the Mount Murray area. Black patches show suggested main concentration of carbonate nodules.

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EXPLANATION OF PLATE 1

Fig. 1 Outcrop about 1.5 m top to bottom, showing siliceous pelletal phosphorite with brown chert interbeds. Monastery Creek.

Fig. 2 XO.6. Close-up of area in fig. 1 marked by dots.

Fig. 3 Polished vertical section. X2. Flame structures in brown chert and pelletal phosphorite beds, from outcrop shown in fig. 1.

Figs. 4, 5 Plain light and crossed polarizers, respectively. X100. Siliceous pelletal phosphorite showing collophane pellets and collophanized shell fragments in groundmass of microquartz and fine grained silica mosaic. Silica in centre field with shadowy extinction. From outcrop shown in fig. 1.

Figs. 6, 7 Crossed nicols. 6, x 100. 7, x 250. Compacted siliceous pelletal phosphorite, showing heavy grain contacts. Cement is microquartz and quartz mosaic. Costean at Mount Murray.

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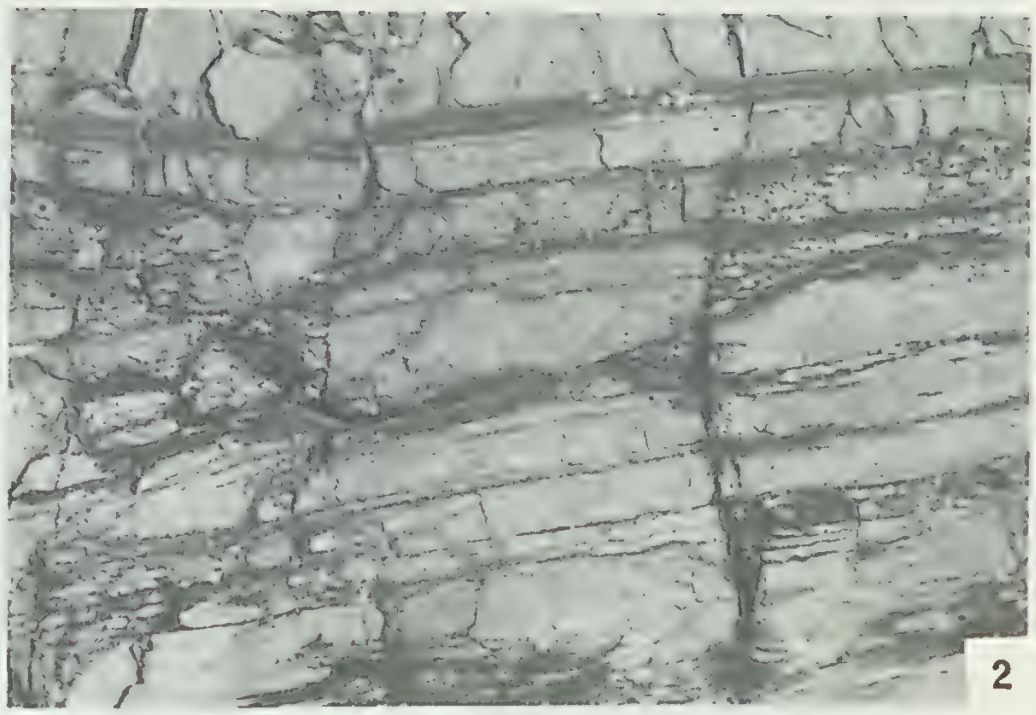

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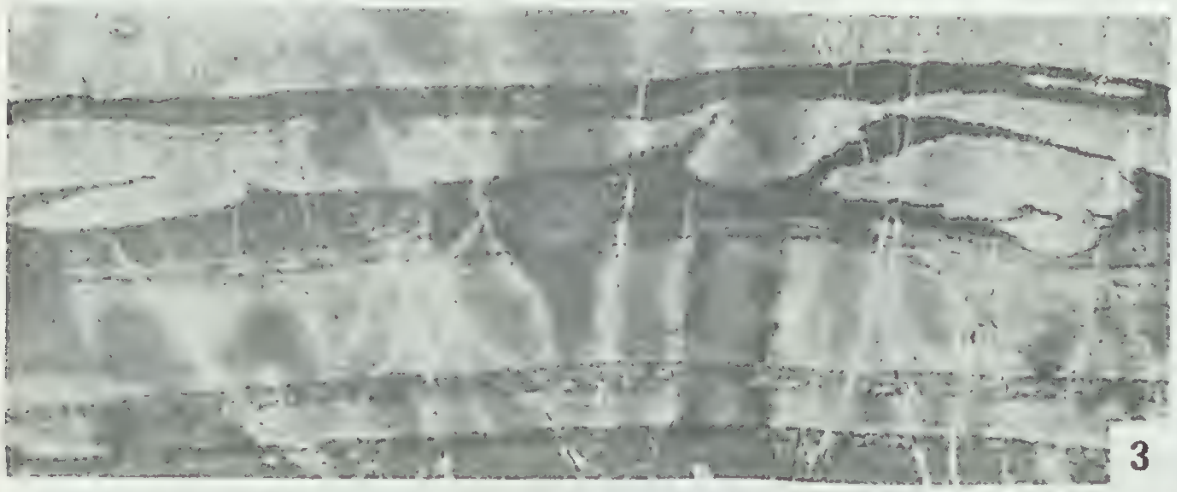

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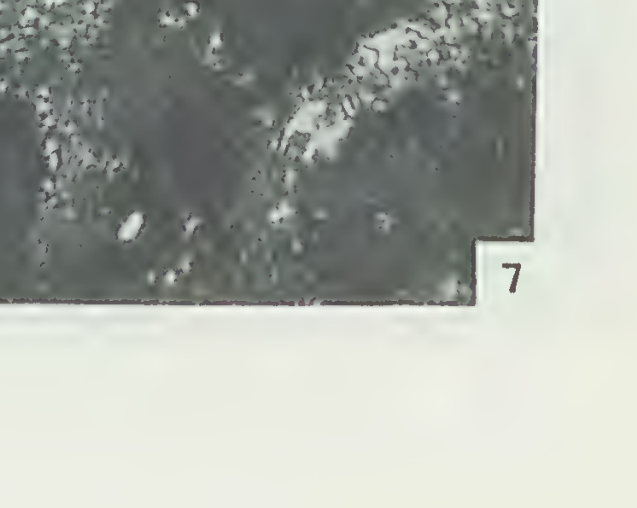

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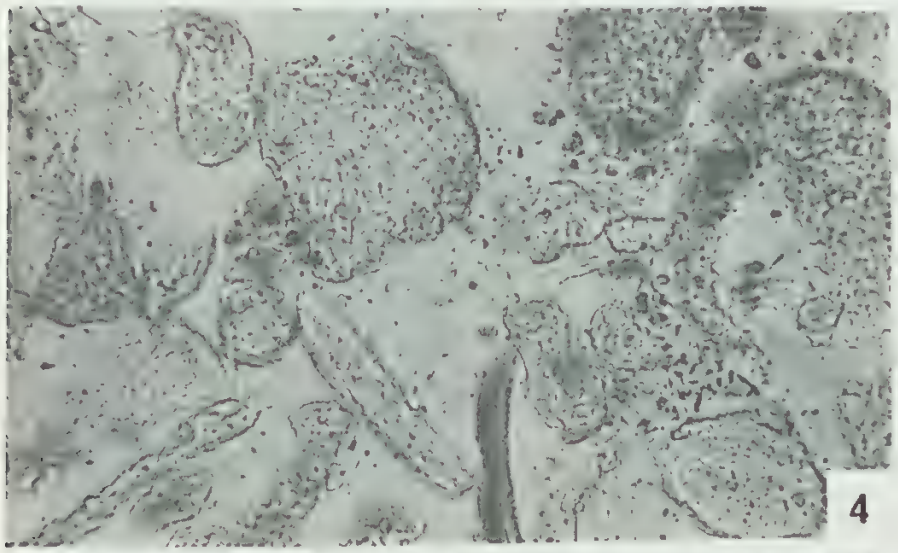

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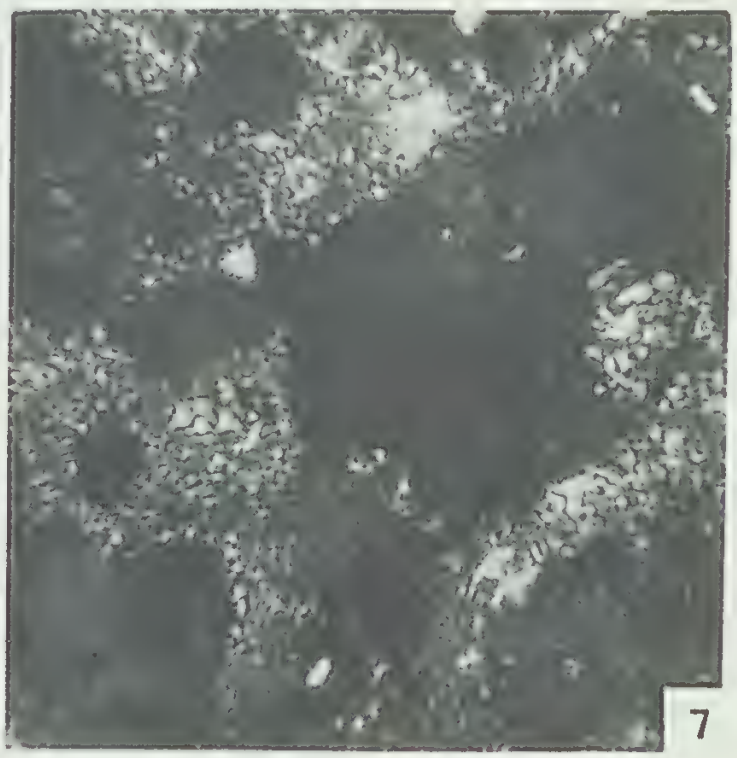

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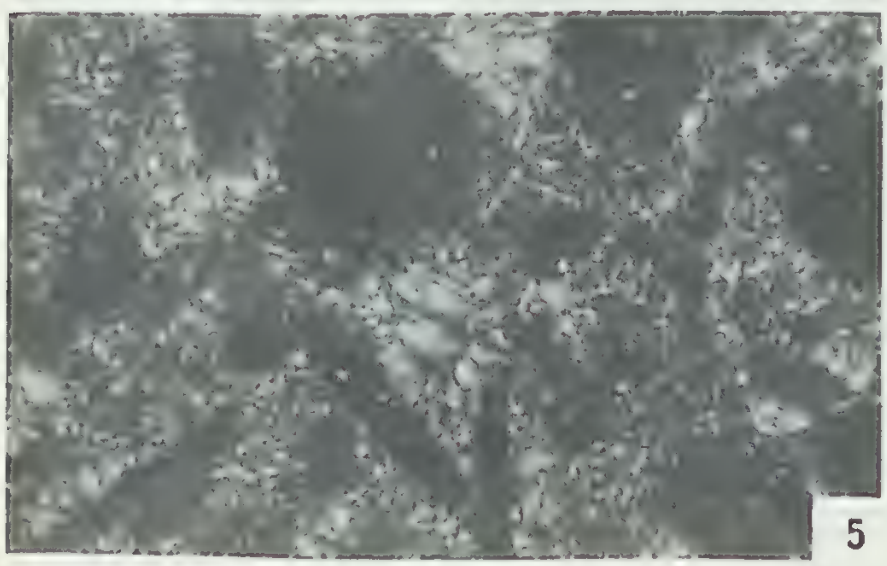

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PLATE 1

EXPLANATION OF PLATE 2

Figs. 1, 2 Plain light and crossed nicols, respectively. X250. Brown chert showing typical fabric of microquartz, a collophane pellet, iron oxide, and some relict black rhombs. From 17 m in DDHD9, about 2500 m north of Mount Murray.

Figs. 3-11 Views of specimen P61-4, from outcrop 0.8 km north of Mount Murray.

Fig. 3 Weathered vertical surface. X1.

Fig. 4 Polished and etched vertical surface. X1. Showing dark lime mud beds, light collophane pellet beds, and silicified area at upper right with partly silicified band between it and unreplaced carbonate.

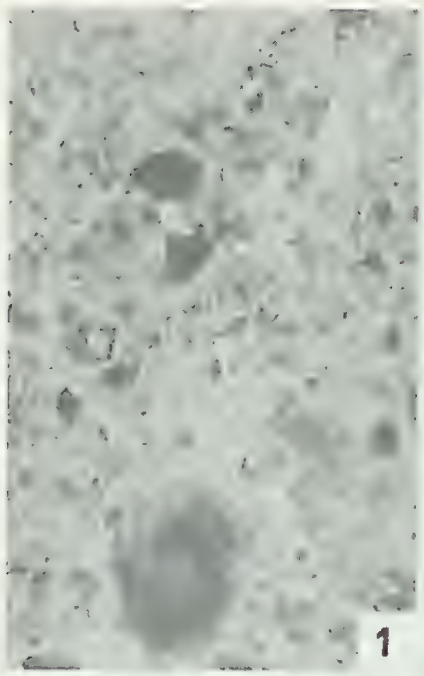
Fig. 5 X4. Detail of contact between silica and carbonate. Silica has not invaded pellet bed at top right, and has advanced only to the arrow in the middle pellet bed. Hazy band is area of partial replacement of carbonate by silica.

Fig. 6 Crossed nicols. X100. Thin section in position shown by cross in fig. 5 above. Pseudospar, recrystallized lime mud, partly replaced by microquartz which is darker and continuous.

Fig. 7 Plain light. X100. Brown chert from far right hand side of specimen, showing numerous relict black rhombs and fine inclusions.

Fig. 8 Plain light. X100. Brown chert from nearer the carbonate-silica contact than in fig. 7, with some collophane allochems, and showing a relict black rhomb with carbonate rim above left of centre.

Figs. 9-11 Plain light. X250. 9, relict black rhomb with wide carbonate rim. 10, relict black rhomb with narrow carbonate rim and, below, ghost of carbonate rhomb. 11, relict black rhomb with carbonate rim, and two clusters of iron oxide crystals.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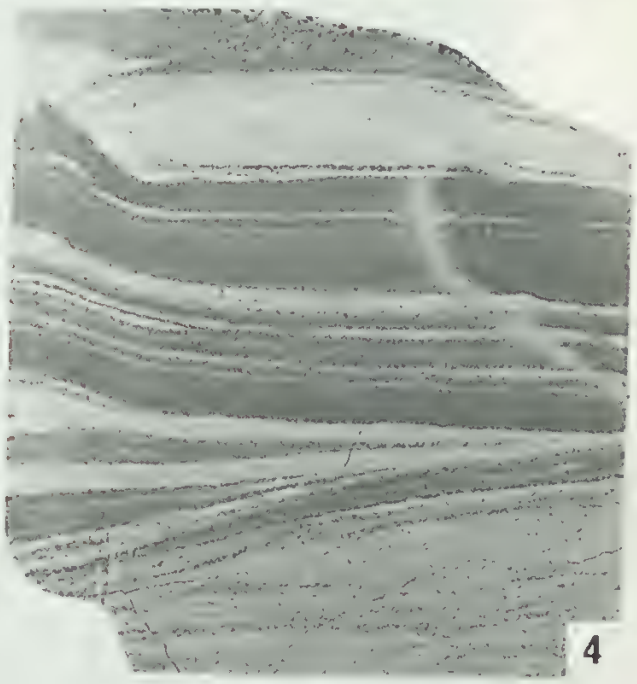
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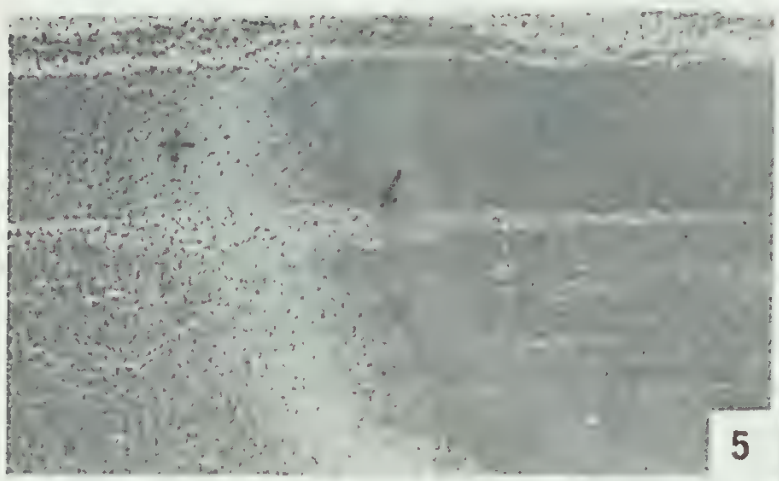
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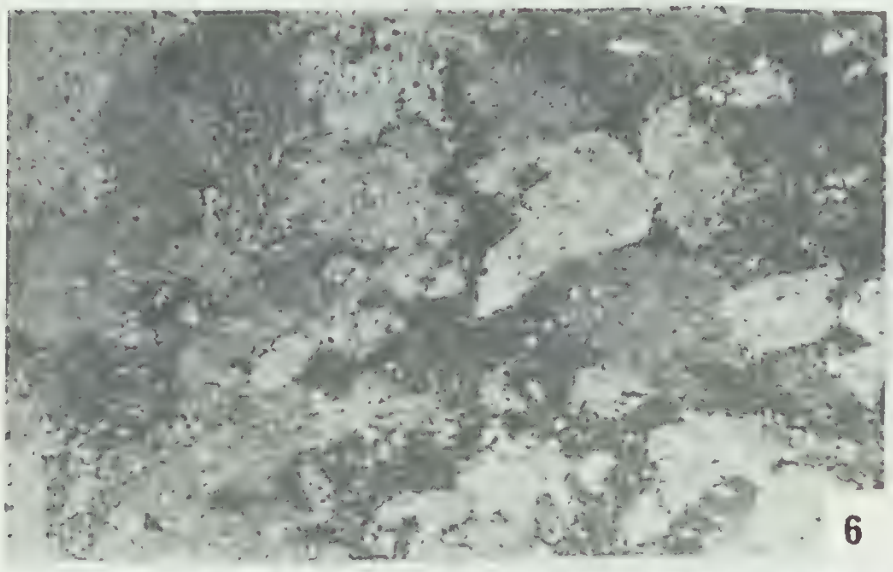
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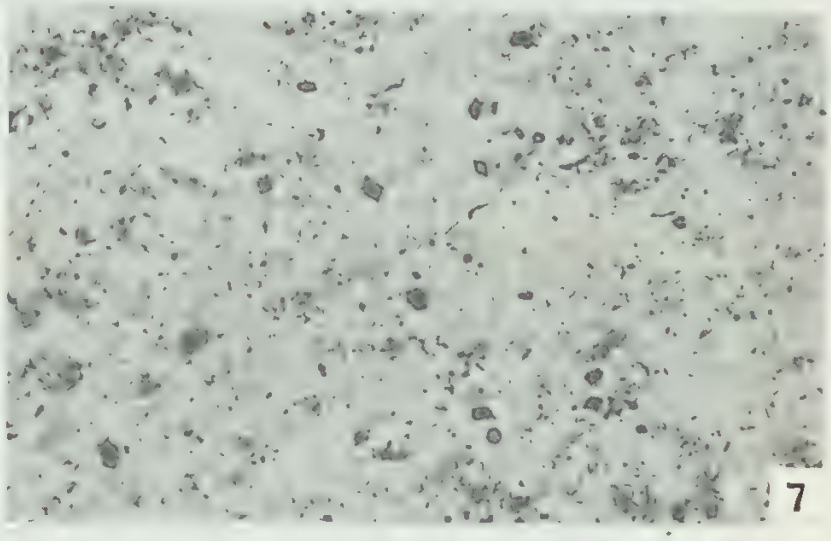
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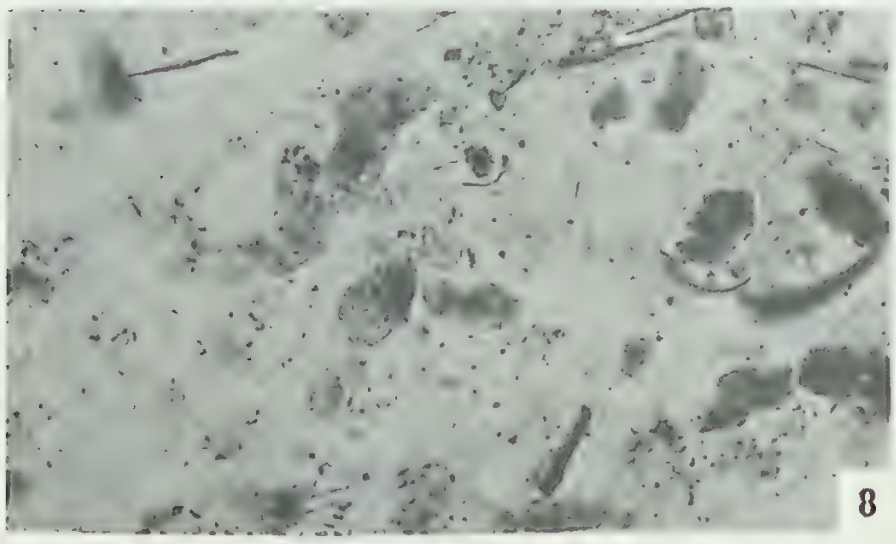
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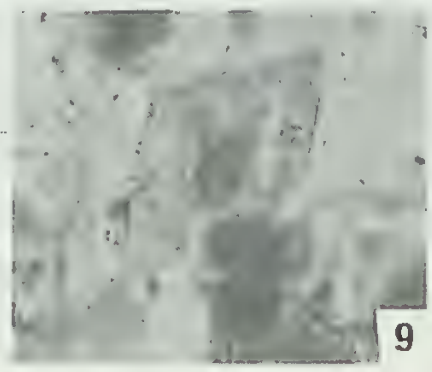
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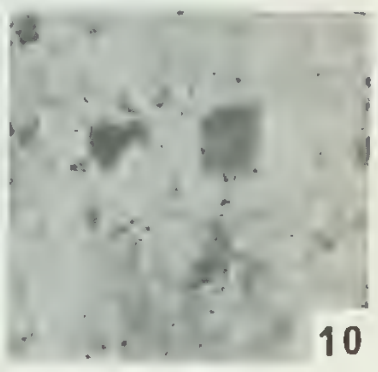
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PLATE 2

EXPLANATION OF PLATE 3

All figures views of specimen P61-3, from 0.5 km north of Mount Murray.

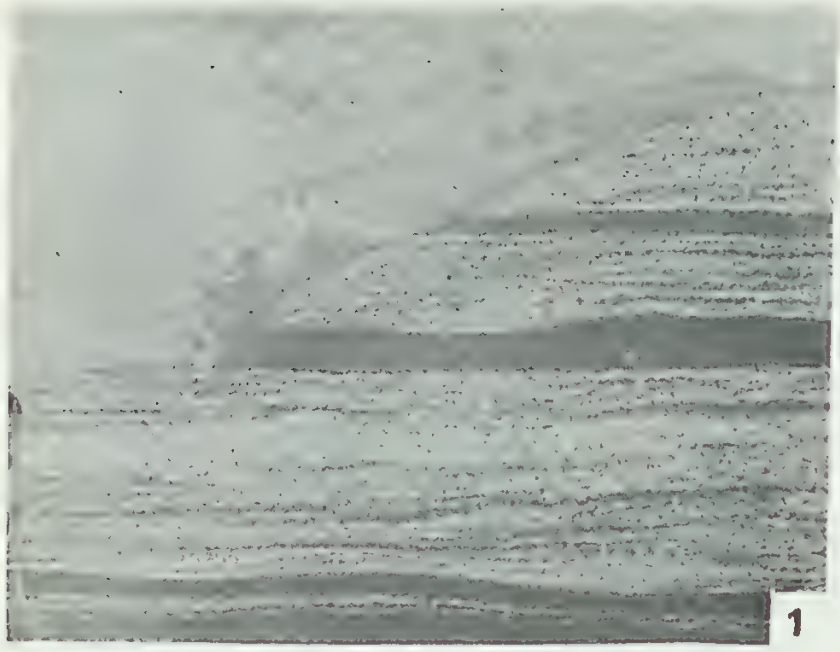
Fig. 1 Polished and etched vertical surface. X1.5. Calcareous nodule with dark lime mud beds at lower right, and compacted pelletal phosphorite cemented by silica at upper left. See also text-fig. 2.

Fig. 2 Close-up of part of fig. 1, showing white lines representing traces of dissolved lime mud beds, with one mud bed and its trace intersecting the silica-carbonate boundary. Dark patches in siliceous phosphorite are groups of phosphate pellets altered to a birefringent mineral.

Fig. 3 Crossed nicols. X100. Contact between silica and carbonate, showing embayed carbonate cement grains isolated in microquartz and fine quartz mosaic groundmass.

Fig. 4 Plain light. X100. Section through a white line of figs 1 and 2, showing pellets squashed together, and all impurities of original lime mud bed concentrated into this narrow band.

Figs 5, 6 Plain light and crossed nicols, respectively. X100. Pelletal bed in calcareous nodule showing collophane pellets and bradoriid shells in calcite cement. Note that pellets appear larger in plain light, where their original outlines can be seen due to organic staining, than in crossed nicols, where calcite can be seen to replace their margins.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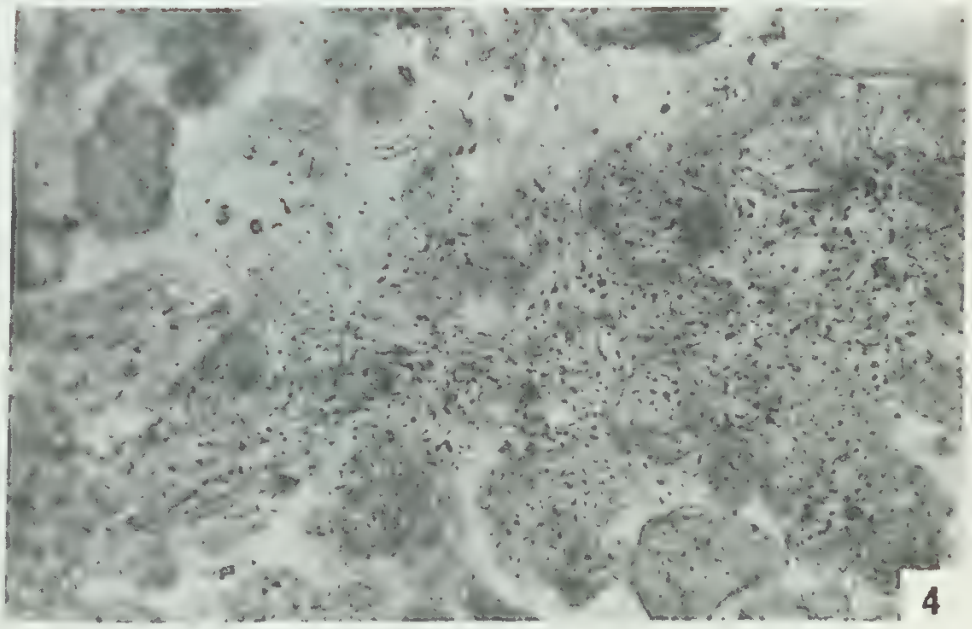
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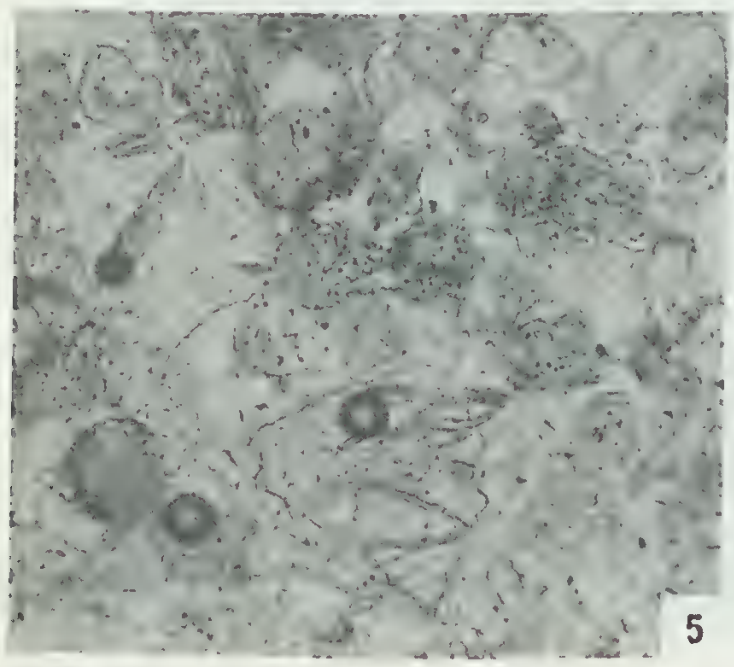
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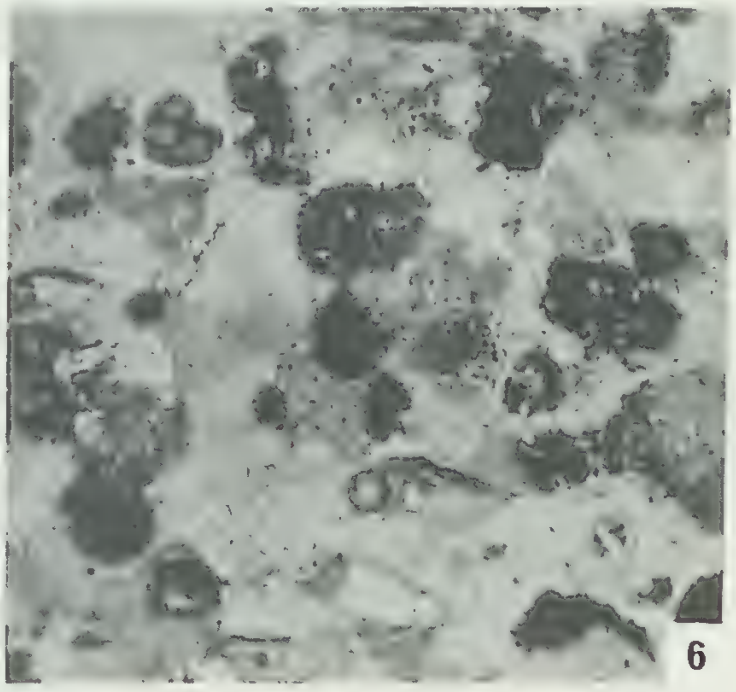
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PLATE 3

EXPLANATION OF PLATE 4

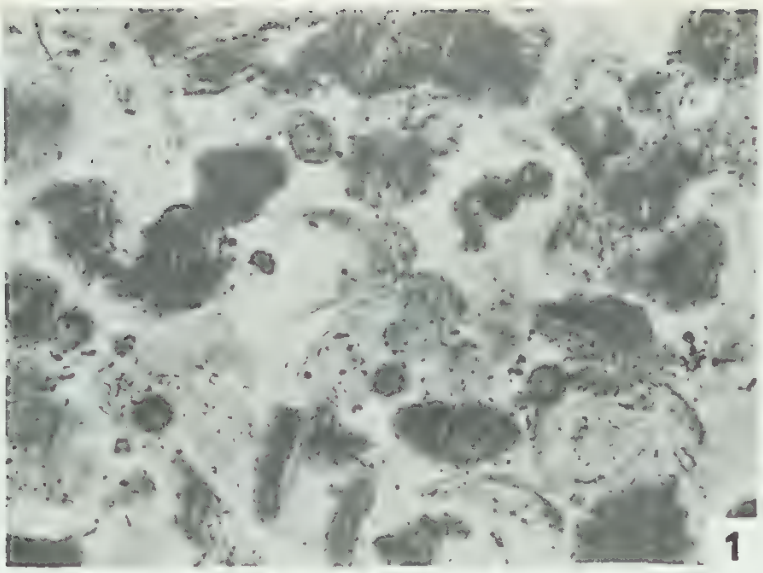
All figs except 7 views of specimen P61-3, from 0.5 km north of Mount Murray.

Figs 1, 2 Plain light and crossed nicols, respectively. X100. Siliceous pelletal phosphorite at upper left of pl. 3, fig. 1, showing more numerous grain contacts than in calcareous beds.

Figs. 3, 4 Plain light and crossed nicols, respectively. X250. Microquartz and calcite in zone of contact between siliceous and calcareous phosphorite, showing embayments in calcite and fine grain size of silica.

Figs 5, 6 Plain light and crossed nicols, respectively. X100. Pseudospar with irregular grain boundaries and numerous inclusions, formed by recrystallization of carbonate mud bed, and with collophane allochem below centre.

Fig. 7 Polished and etched vertical surface. X1.5. Original carbonate beds at right. A and D are pelletal; B, C, and E are recrystallized carbonate mud beds. Left side of specimen is compacted after removal of carbonate. Specimen P50-5, northern slope of Mount Murray. See also text-fig. 3.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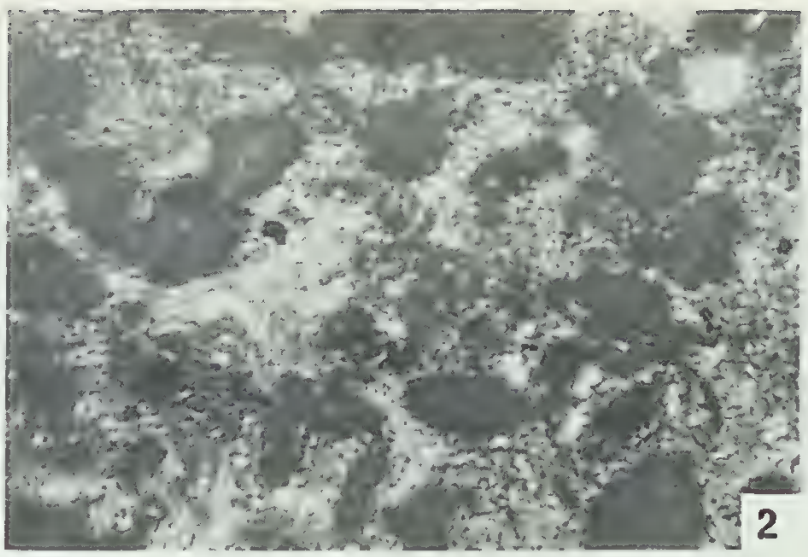
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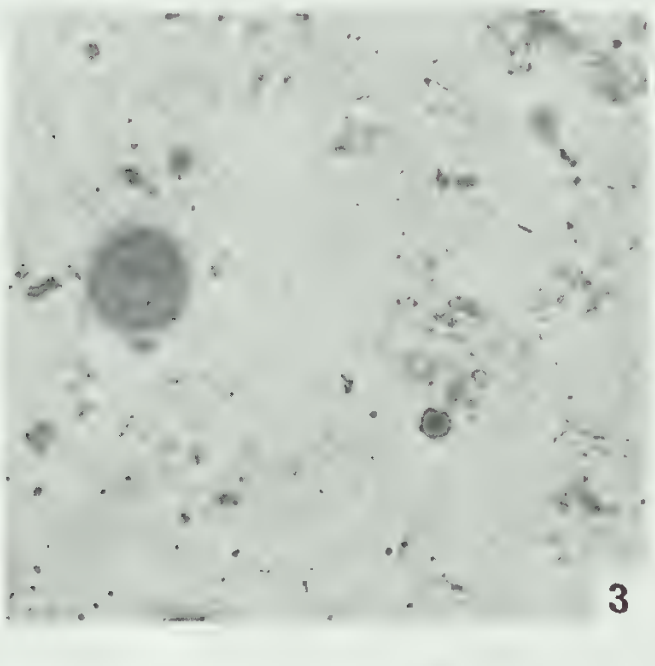
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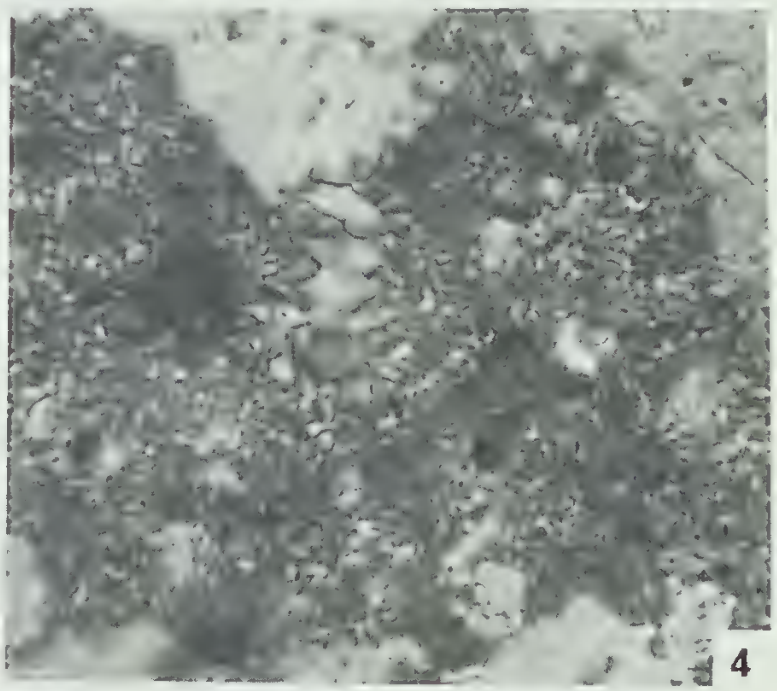
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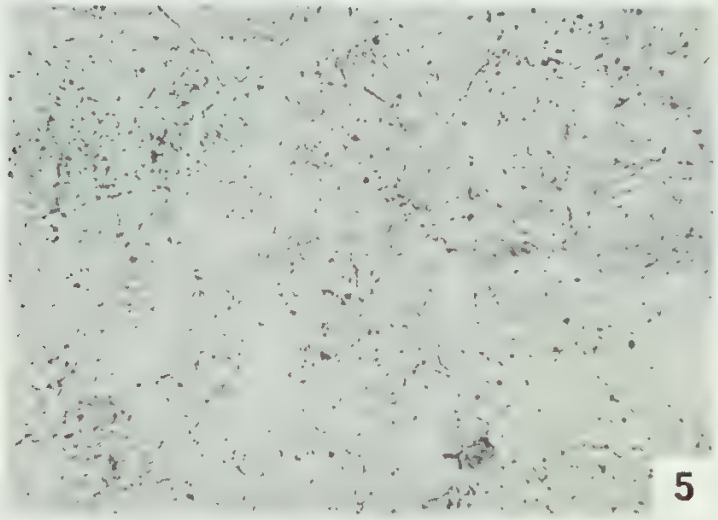
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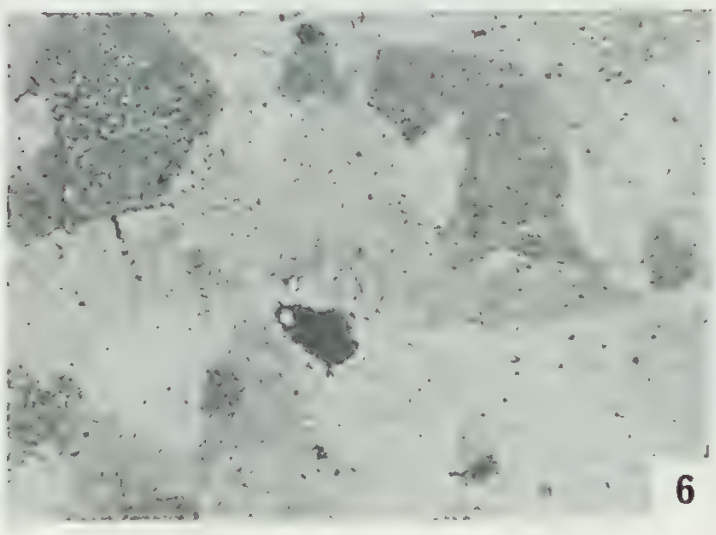
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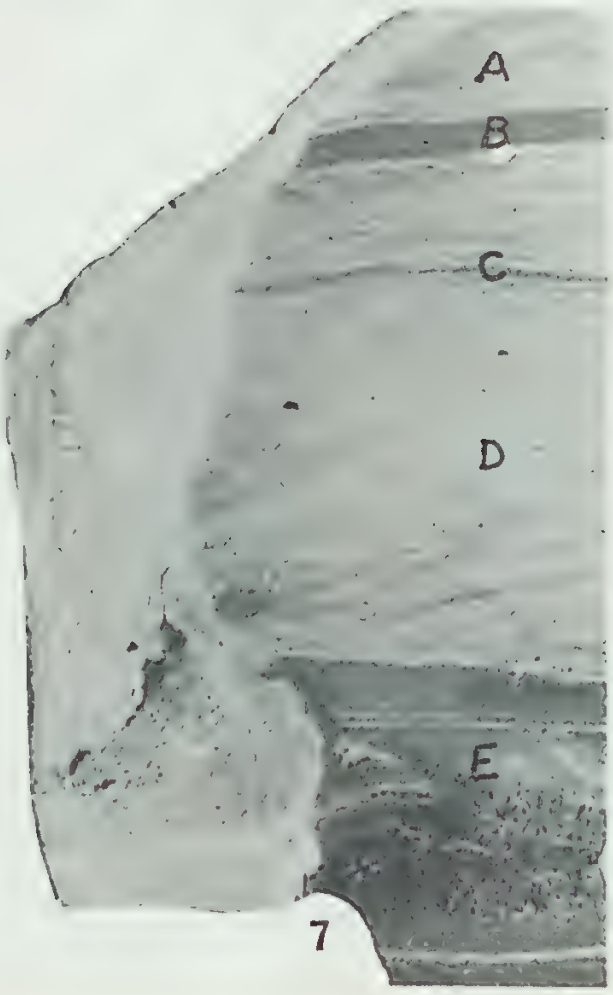

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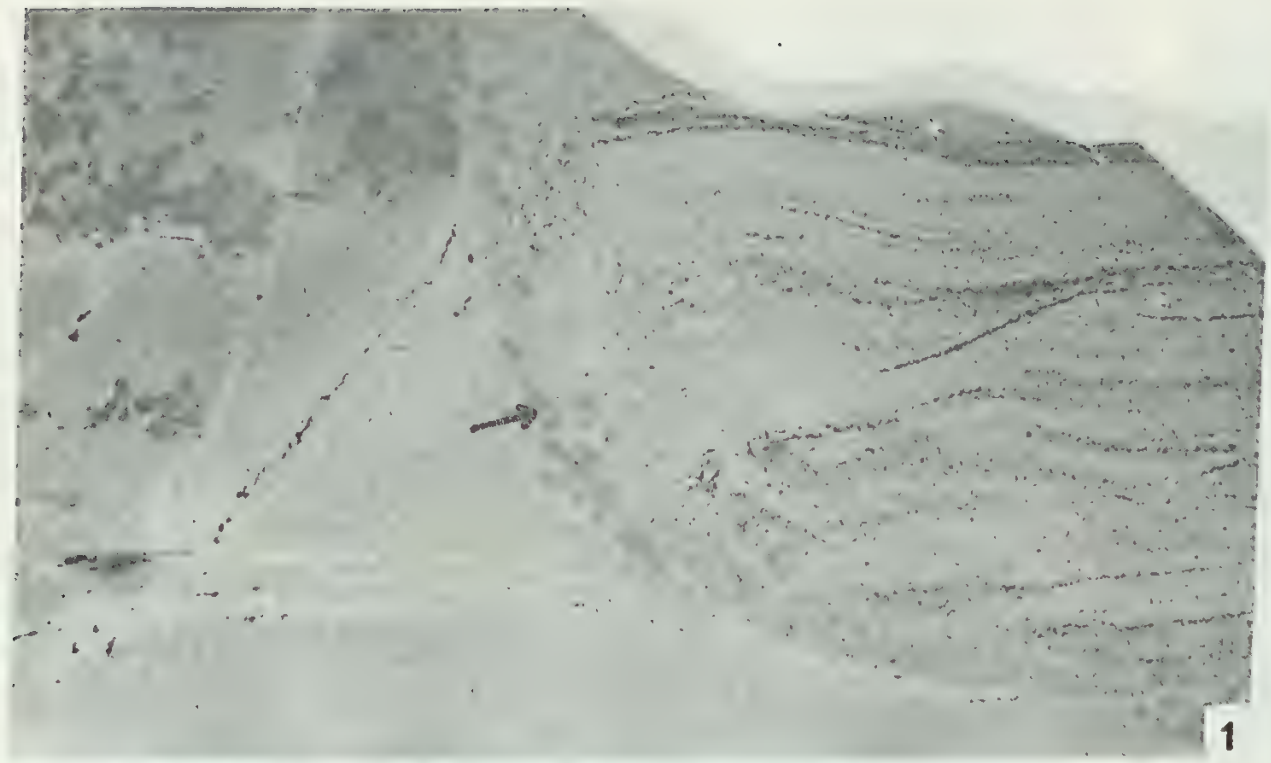
PLATE 4

EXPLANATION OF PLATE 5

Figs. 1-3 Polished and etched vertical surface. 1, x 1. Carbonate nodule at right, with more compacted siliceous pelletal phosphorite at left, showing thin lime mud beds in nodule and patches of birefringent phosphate mineral at left. 2, x 2. Detail of silica-carbonate contact, showing vertical calcite-filled shear cracks near margin of nodule. 3, x 10. Close-up of area near arrow in fig. 1, showing overpacked collophane pellets in compacted siliceous phosphorite. Specimen P61-2, 0.8 km north of Mount Murray.

Fig. 4 Polished and etched vertical surface. X1. Shows light coloured areas, top and bottom, with silica cement and relict lime mud beds. Specimen 40.24, from costean at Mount Murray.

Figs. 5; 6 Polished and etched vertical surface. 5, x 1. 6, x 10. Calcareous nodule at right with lime mud bed and numerous fossil shells. Siliceous phosphorite at left, where shells are apparently rare due to being compacted among other allochems. Specimen P61-1, 0.8 km north of Mount Murray. See also text-fig. 4.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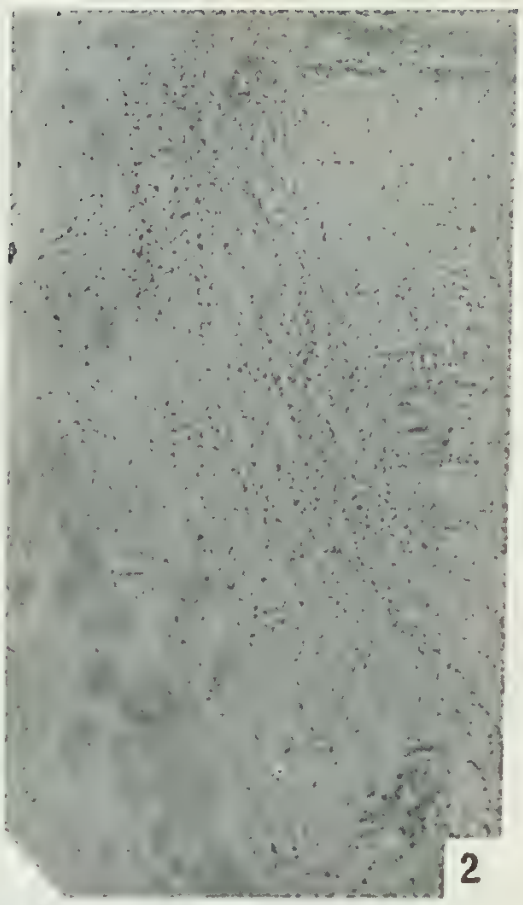
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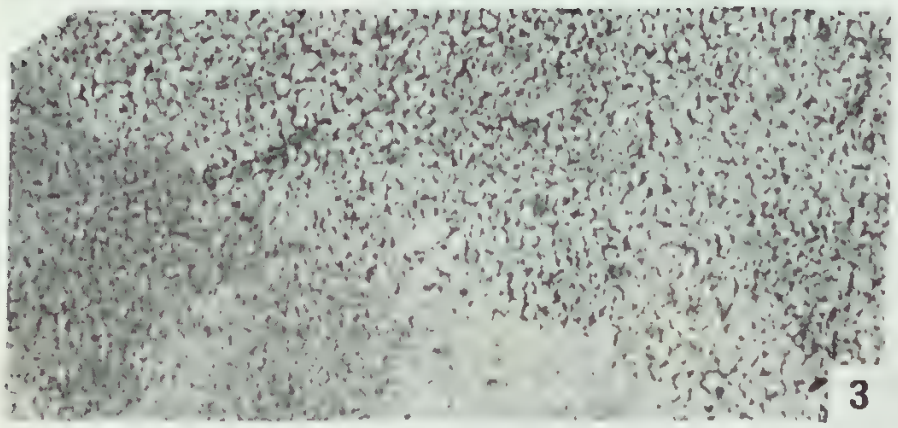
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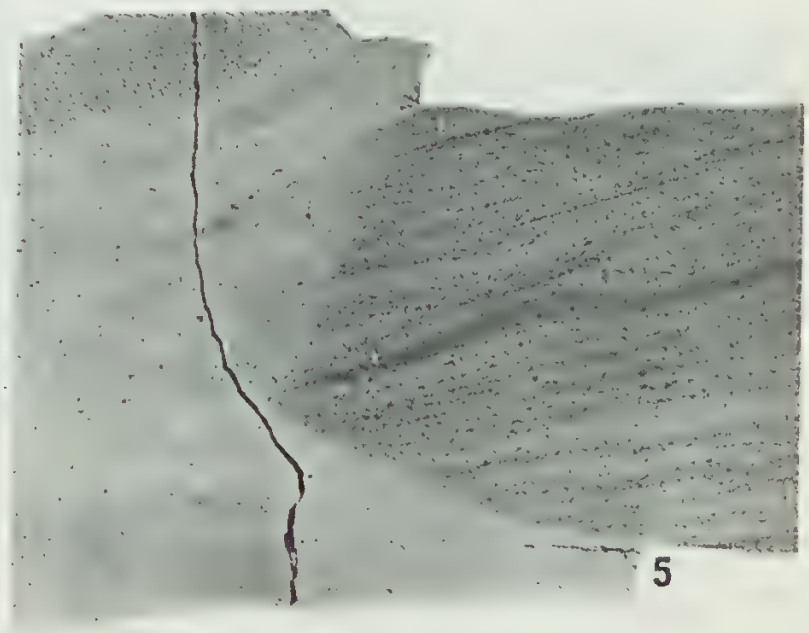
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PLATE 5

EXPLANATION OF PLATE 6

All figures except fig. 4 are views of specimen P61-7, from northern slope of Mount Murray.

Fig. 1 — Polished and etched vertical surface. X0.7. Calcareous nodules in compacted pelletal phosphorite (beds A and C), and showing chert bed B distorted by compaction.

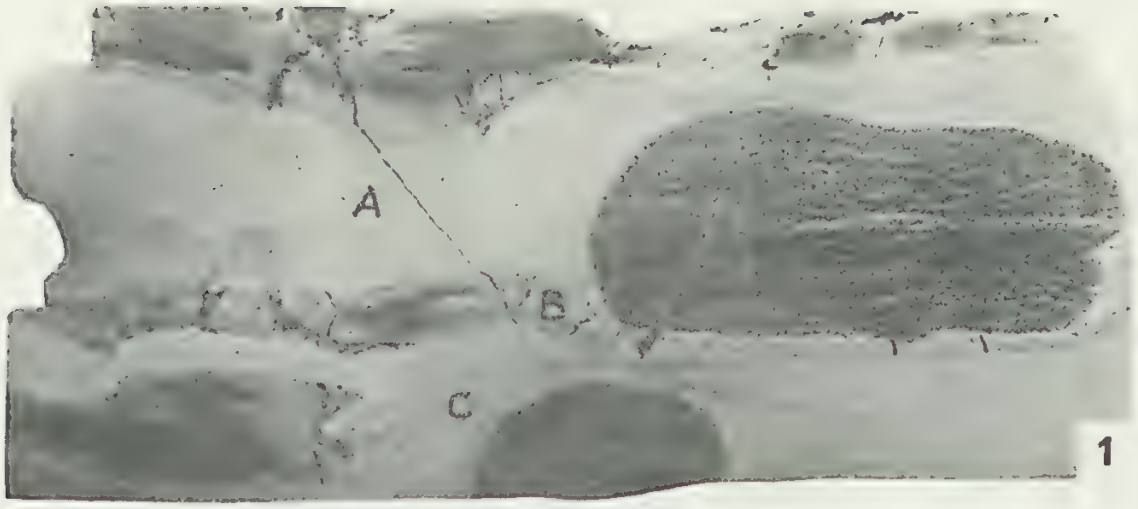
Fig. 2 — Same surface. X1.75. Showing cracks in chert bed B and nodule, filled partly by phosphorite and partly by calcite. See also text-fig. 6.

Fig. 3 — Polished and etched vertical surface parallel to that of previous figures. X0.6. Shows degree of compaction in bed A and distortion of bed B and other siliceous nodules. See also text-fig. 5.

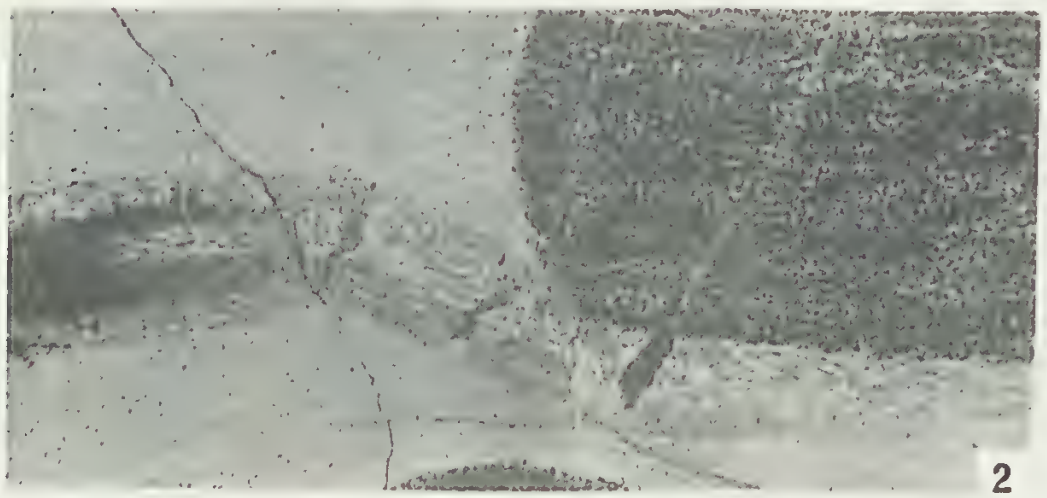
Fig. 4 — Weathered vertical surface. X0.5. Shows strong disruption of chert beds and disorientation of carbonate nodules, due to compaction. Specimen P61-8, northern slope of Mount Murray.

Figs. 5, 6 — Plain light and crossed nicols, respectively. X100. Shows fabric of carbonate nodules; micrite pellets, collophanized micrite pellets, and collophane pellets in clear calcite cement.

Fig. 7 — Crossed nicols. X100. Compacted phosphorite of bed A in figs 1 and 3 above, showing mylonitized fabric of crushed shells, pellets, and carbonate groundmass.



1



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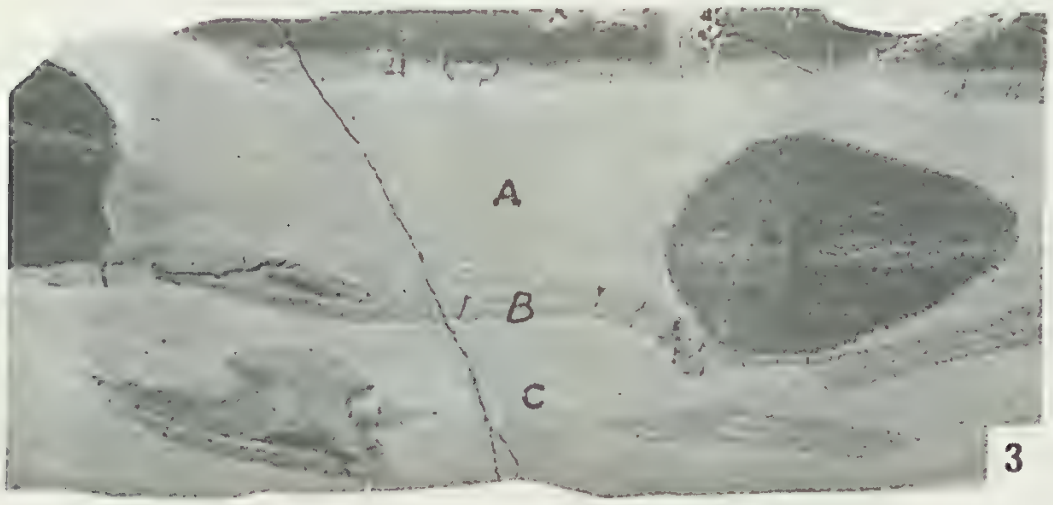

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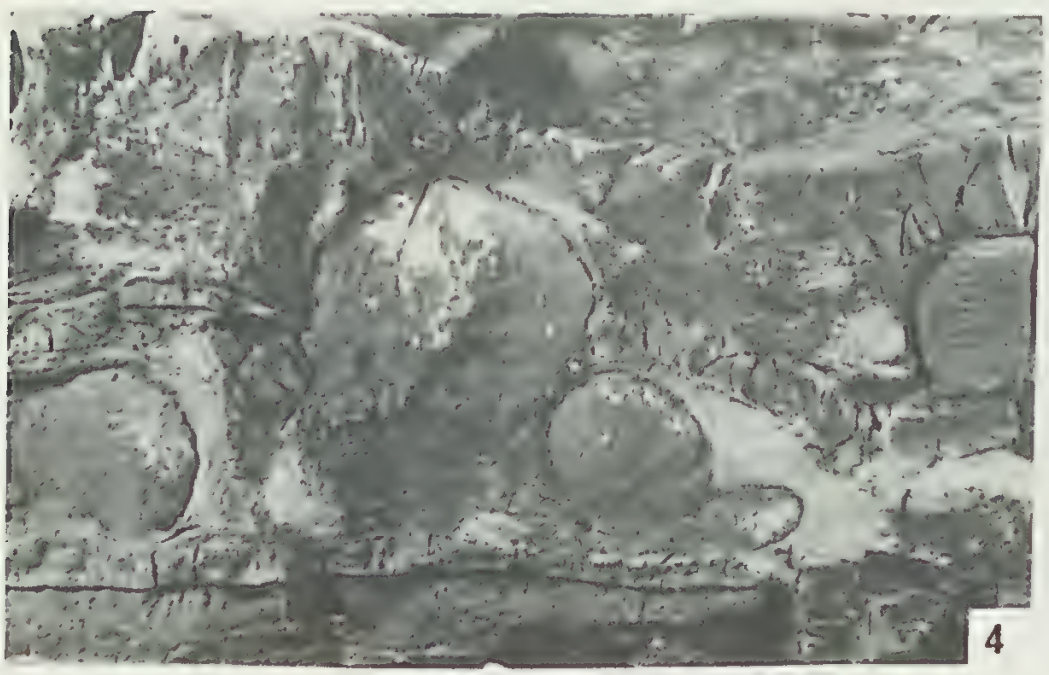

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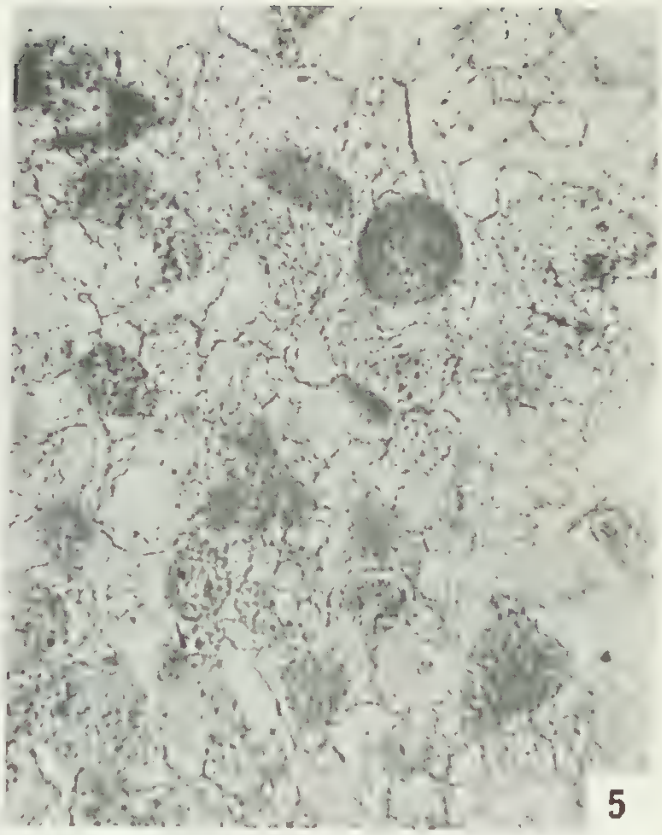

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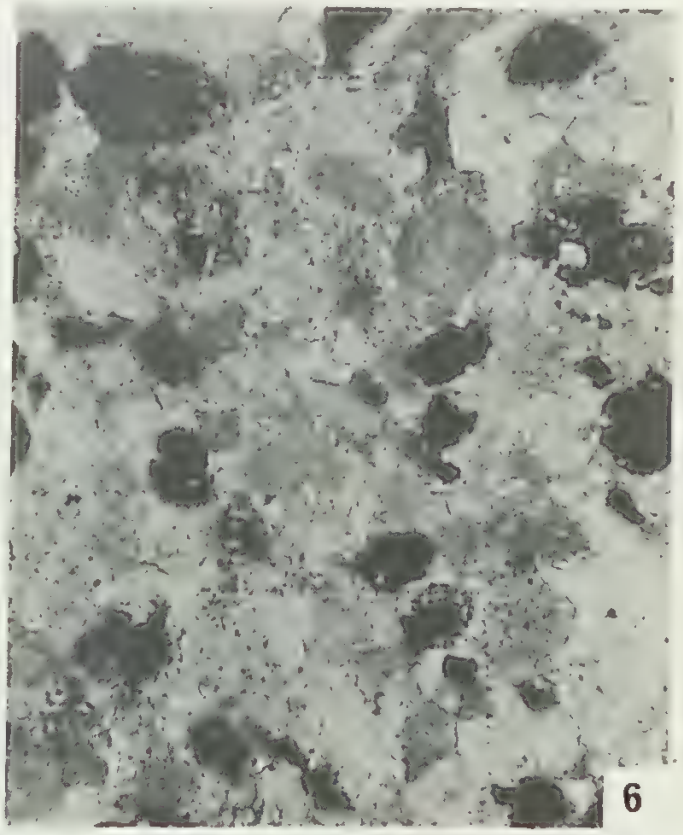

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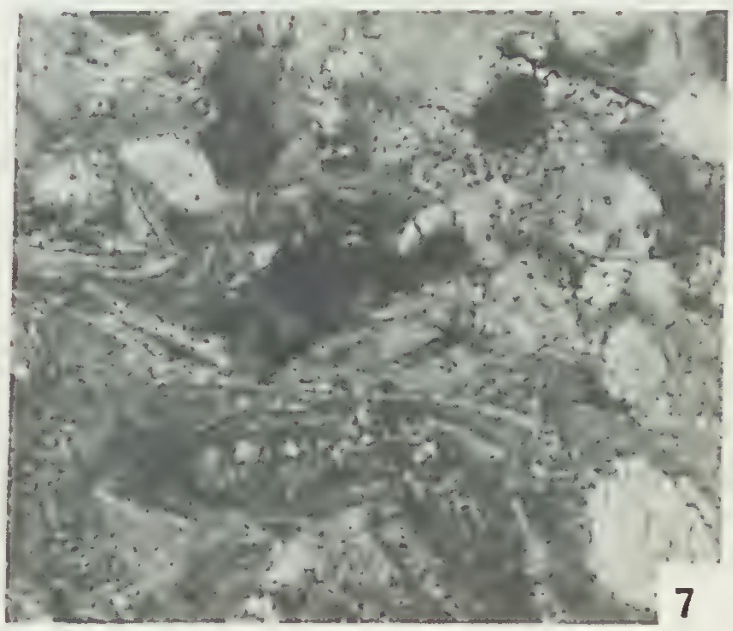

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PLATE 6

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